# ROLE OF GROUNDWATER IN THE DEVELOPMENT OF AGRICULTURE IN ALIGARH DISTRICT

DISSERTATION SUBMITTED FOR THE DEGREE OF

**Master of Philosophy**

IN

**GEOGRAPHY**

BY

**MD. IRFAN SABIR**

Under the Supervision of

**DR. AZIMUDDIN QURESHI**
Reader

DEPARTMENT OF GEOGRAPHY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

1990

*Phone : 5661*

DEPARTMENT OF GEOGRAPHY
ALIGARH MUSLIM UNIVERSITY
ALIGARH

13.11.90

## CERTIF ICATE

*This is to certify that* Mr.Md.Irfan *Sabir has* completed his dissertation for the award of the degree of M.Phil. entitled 'Role of Groundwater in the Development of Agriculture in Aligarh District' under my supervision.The work is an original contribution to the existing knowledge of the subject.

He is allowed to submit the work for the award of the degree of M.Phil.

Dr.Azimuddin Qureshi
Supervisor
READER

**ACKNOWLEDGEMENTS**

It is indeed a matter of great pleasure to express my grateful thanks to my supervisor **Dr. Azimuddin Qureshi**, Reader, Department of Geography, A.M.U., Aligarh for his valuable supervision and guidence for the preparation of this dissertation. Without his proper guidence and constructive suggestions the work have not been completed.

I wish to express my deep sense of gratitude to **Mr. Mohammad Sami Ahmad**, Reader in Hydrogeology, Department of Geology, A.M.U., Aligarh for his valuable guidence, suggestions and constant encouragement throughout the work.

I am also deeply indebted to **Prof. M. Farooq Siddiqi**, Chairman, Department of Geography, A.M.U., Aligarh for providing necessary research facilities.

I wish to express my sincere thanks to **Dr. Mohammad Shafi**, Emiretus Professor, in the Department of Geography, A.M.U., Aligarh for his encouragement and help in the preparation of my dissertation.

It is pleasurable to render my sincerest thanks to **Mr. Akram Ali**, a research scholar in the Department of Geology for his constant help at various stages of my research programme.

My sincere thanks are also due to **Mr. Firoz Javed**, S.T.A, Geochemical Laboratory, Department of Geology, A.M.U., Aligarh for his kind co-operation in carrying out the analytical work. I am thankful to my senior research fellow and friends M/S **Admad Saeed Siddiqui**, **Imran Khan**, **Zulfequar Ahmad Khan**, **Shamim Akhter** and **Shakir** who helped me to complete the research project in various ways.

I feel short of vocabulary to express my heart felt thanks to my **mother** whose love and affection has always been a source of inspiration for me. My special thanks are due to my **elder brothers** who encouraged me every time and provided me full financial support without which my study would have not been possible.

Md. Irfan Sabir

( MD. IRFAN SABIR )

# C O N T E N T S



.....

## L I S T  OF  T A B L E S

# LIST OF FIGURES

## LIST OF APPENDICES

# C H A P T E R - I : INTRODUCTION

- Location, Extent and communication
- Previous work
- Methodology

# INTRODUCTION

In order to give a boost to the foodgrain production programme, a high priority has been given to water resource evaluation, development and management. Agriculture is a soil-plant-water system. In a soil-crop-water system, it is the water whose presence makes the land green or its absence converts the land into desert. Our water resource development programme has two main components, surface water and ground water. The largest available source of fresh water lies under ground, which is called groundwater. With the advent of planning at district level, the block level, ground water resource estimation has attained a great importance.

Groundwater resources contributes over 50 per cent of irrigation potential created in the country, which very well testifies the role of groundwater in agriculture. The gross groundwater recharge in the country is 458 million $m^3$ and the net utilisable groundwater recharge works out to be 321 million $m^3$. The present groundwater utilisation in the country is 125 million $m^3$ leaving a balance of 196 million $m^3$ of groundwater still available for further development and utilisation. It can be stated that the ultimate feasible irrigation potential from groundwater resources in the country is 40 million hectares and by the year 1979-80, 22 million hectares i.e. mearly 55 per cent of ultimate feasible potential are being provided irrigation by groundwater. The target for the Sixth Five Year Plan (1980-85) to provide Irrigation by groundwater to 7 million nectares in the first two years of the Plan (1980-82), about 1.45 million hectares have been provided irrigation through groundwater resources. The fact that out of the total ultimate feasible irrigation potential by all sources of 113 million hectares in the country, the share of ground water is 40 million hecatres, clearly indicates the importance of groundwater resources in providing irrigation in the country (Pathak, 1985).

In the year 1951, the cropped area was at 142.2 million hectares where as the irrigation facilities were provided 22.2 million hectares. The total area under irrigation over these years have increased to 68 million hectares but at the same time the area under crop has also increased. It is estimated that by 2025 AD, the total utilisable surface and groundwater resources would be exploited providing irrigation to 113 million hectares whereas the area under crop will increase to 200 million hectares. Thus a large area will still remain under rainfed agriculture. This calls for efficient management of water resources with emphasis on maximum return per unti use of water.

The achievement so far in developing ground water to meet the irrigation needs in the country are commendable. Further, in all Canal command areas in the country particularly in Ganga Basin, excessive application of surface water has resulted in serious conditions of water logging and soil salinisation. In all such situations detail hydrogeological studies involving the amount of seepage and management of ground water reservoir are very essential. Conjunctive use of surface and ground water will greatly help achieve the safe and optimum utilisation of water in such areas. The situation demands a fresh look on all our ground water resources in the country.

In the above context, it has become very important to make a refined quantitative evaluation of our ground water resources right from the block level and then at district level such investigation will depict a harmonious hydrogeological picture of the country, encompassing blockwise occurrence, behaviour, quality, state of development, quantity of usable ground water resources and scope of its further development.

The study shows that the ground water development in Dhanipur Block is being done on large scale through the shallow farmers tubewells. The assured irrigation through ground water has revolutionised the food production in the

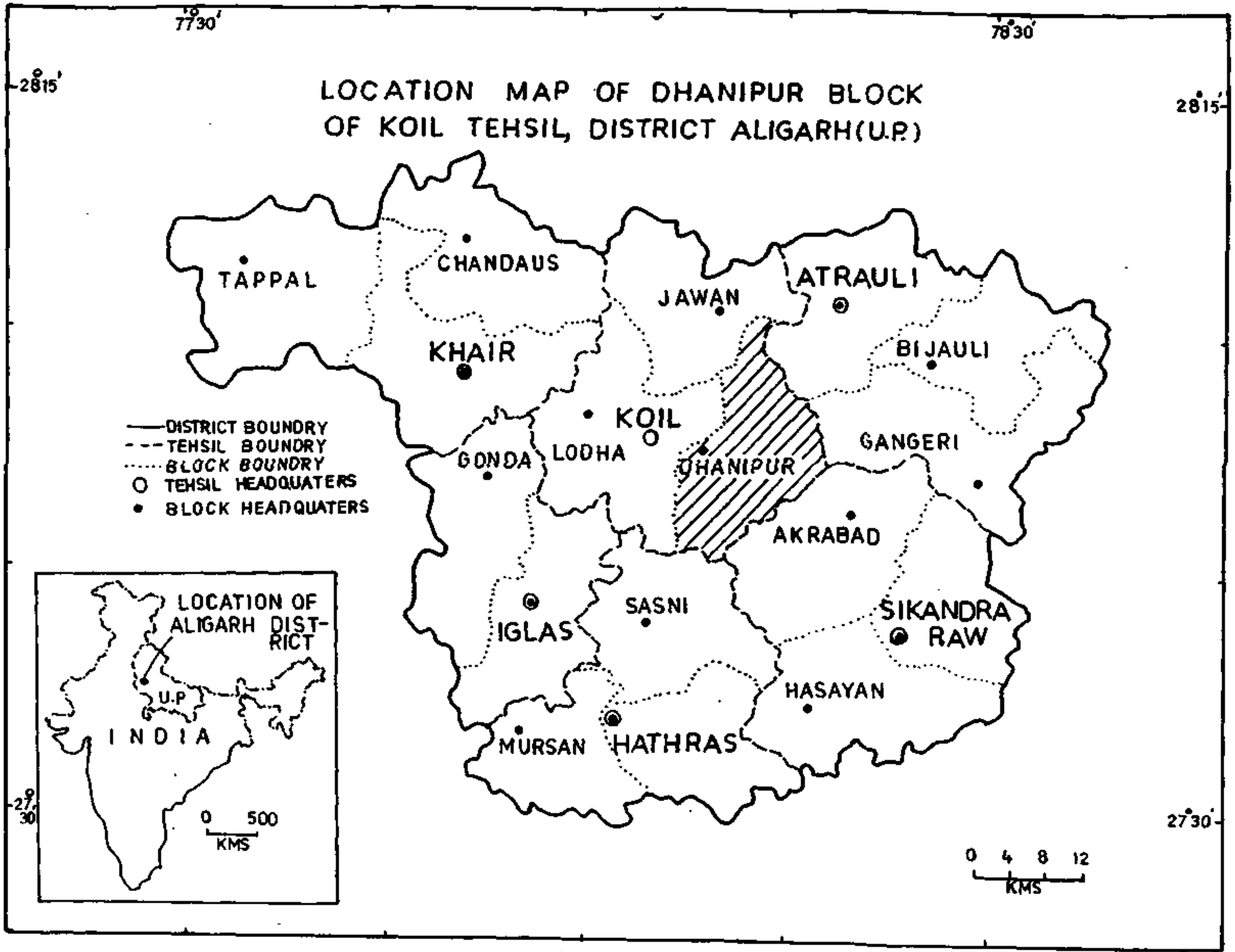

LOCATION MAP OF DHANIPUR BLOCK
OF KOIL TEHSIL, DISTRICT ALIGARH (U.P.)
77°30'
78°30'
28°15'
28°15'
27°30'
27°30'
TAPPAL
CHANDAUS
KHAIR
JAWAN
ATRAULI
BIJAULI
KOIL
LODHA
GONDA
DHANIPUR
GANGERI
AKRABAD
IGLAS
SASNI
SIKANDRA RAW
HASAYAN
MURSAN
HATHRAS
DISTRICT BOUNDRY
TEHSIL BOUNDRY
BLOCK BOUNDRY
TEHSIL HEADQUATERS
BLOCK HEADQUATERS
LOCATION OF ALIGARH DISTRICT
U.P
INDIA
0 500
KMS
0 4 8 12
KMS

Fig.—1

block which very well testifies its role in transferring the rural land scape and the economy of the people, in the area. High yielding varieties of the crops like wheat, paddy and also vegetables need assured irrigation in time. Surface irrigation is also available but it is not assured irrigation due to lack in management and political exploitation. It creat water logging near the main canal while water could not reach in the fields through the distributaries away from the main canal, so the farmers need their own shallow tubewells for assured irrigation. As the data based on survey shows that ground water resource is available for irrigation, so the government should manage more shallow tubewells for the farmers for irrigation to increase the foodgrain production in this area.

## LOCATION, EXTENT AND COMMUNICATION

Aligarh is one of the most prominent districts of the Ganga Yamuna Doab and forms a part of Central Ganga basin. It consists of three distinct physiographic units. The eastern and western uplands and the central depression. The Dhanipur Block of Koil Tehsil forms a part of central depression and imparts of the western margin of the eastern upland, covering an area of 293.94 Sq km. It lies between latitudes 27°46' to 28°2' North and longitudes 78°5' to 78°18' east and falls in the survey of India toposheet No $54\frac{I}{I}$ . The area is well connected with roads and railways, Fig-1.

PREVIOUS WORK:

The area has been studied by the Officers of the G.S.I. and the Central Ground Water Board in the late sixties.

In all 48 deposit Wells and 2 exploratory tube-wells have been drilled down to the depth ranging between 60.35 to 383.26 m. b.g.l. by the Central Ground Water Board upto 1980-81. The bed rocks were encountered at Salempur about 20 km south-west of Aligarh city and near Aligarh Railway Junction respectively. The bed rock encountered at Salempur at 286.94 m.b.g.l. is Upper Bhander Sand Stone and that at Aligarh Railway Junction is red shale at 340 m.b.g.l. which belong to Upper Vindhyan Bhander Group.

Dutt (1969) studied the Hydrogeology of Aligarh district and concluded that the aquifers are inter-connected in nature. He has attributed the large scale water logging condition and attained soil salanisation to the excessive seepage of Upper Ganga Canal into the underlying shallow aquifers. He suggested large scale development through deep tubewells as an effective measure to control the rising water table and at the same time meeting the irrigation needs in view of the iterconnected nature of the aquifer system.

Fahmi and Nazir (1986) made an attempt to study the general ground water conditions in the A.M.U. campus. Ahmad et al., (1988) had published an interesting paper on ground water management in A.M.U. campus and conclude that water table is declining at the rate of 0.36 m/year. Ali, (1987) have studied the hydrogeology of A.M.U., campus and around covering a small portion of Dhanipur Block in detail. He concluded that the area displays two extreme ground water situations, that is, the eastern upland through which passes the Upper Ganga Canal shows accute water logging and soil salinization where as the central depression encompasses the Aligarh Muslim University Campus evinces a decling trend of ground water level. Further he has pointed out that the ground water from shallow aquifer is not suitable for drinking purposes. To containt the above problems, construction of canal through A.M.U. campus, tapping of deeper aquifer and of improvement of the drainage system and treatment/municipal and industrial waste water has been given as some of the remedies by the author.

Although the general groundwater conditions throughout the Ganga basin are known, the detail information necessary for meaningful quantitative estimates of groundwater resources is known only for a small part of the basin.

<u>METHODOLOGY</u>:

The available hydrogeological information was collected from the published and unpublished reports of Geological Survey of India (GSI), Central Ground Water Board and Oil and Natural Gas Commission (ONGC).

Systematic well inventory of 86 dug wells and 8 tubewells (shallow and deep) were carried out and relevant hydrogeological data were collected in order to study the general ground water conditions, behaviour of water table, its occurrence and movement in the area.

To ascertain sub-surface geological frame work, bore hole data of the state tubewells in Dhanipur Block were utilised and cross-section were prepared in order to illustrate the aquifer system in the area.

In order to study the ground water quality in all 37 ground water samples/were collected during June, 1989 from open wells spread over the entire area. The water samples collected were put to partial and complete chemical analyses in the Geochemical Laboratory of the Geology department, A.M.U. Aligarh.

In order to study the variability of rainfall, occurrence and frequency of drought and recharge from rainfall, the rainfall data of Aligarh raingauge station was collected. Data pertaining to major and minor Irrigation schemes were also collected from State Government agencies so as to estimate the surface water storage and its contribution to ground water reservoir.

......

## C H A P T E R - II : PHYSIOGRAPHY

- Drainage
- Soil types
- Land use pattern
- Climate and rainfall

## P H Y S I O G R A P H Y

The Dhanipur Block of Koil Tehsil, District Aligarh may be divided into following three distinct physiographic units.

1. Central depression
2. Eastern Upland
3. Kali Khadir

CENTRAL DEPRESSION:

This depression lies between the eastern and western uplands. The Dhanipur Block forms a part of this Central depression which runs in north-west to south-east direction. The depression is a prominent linear feature which encompasses the districts of Meerut, Bulandshahr, Aligarh and Etah. Entering the north of Koil Tehsil it passes through the Dhanipur Block and other parts of Koil Tehsil and enters into Sikandra Rao Sub-division occupying practically all the south western corner of the Tehsil and finally passing into Etah. This tract is characterised by a clayey soil, imperfect natural drainage and numerous Jhils in which the surface water collects without finding an adequate outlet. As regard its origin various possibilities are:

i) it may an abandoned channel of some big river,

ii) possibly represents a sagging or a structural dislocation in the bed rock topography which was later filled up by the Ganga and its tributaries. The level varies from 193 m at Bulandshahr-Aligarh district junction in north-west to 173.78 m at the south eastern and of the district giving an average gradient of 0.2 m.to a km.

**EASTERN UPLAND:**

It is actually the western margins of the eastern upland which lies between the high sandy bank of Kali river and extend westward upto the canal. It is a rich tract of excellent loam and fully irrigated.

The tract of the upland possesses the patches of sandy soil which are locally known as Bhur. Beyond the canal lies the broad central depression. The general slope of this tract is about 0.28 m/km due south.

**KALI KHADIR:**

Kali Khadir lies both on the left and right bank of Kali Nadi. The soil of Khadir comprises sandy loam above this

Khadir riser the Sandy Bank of Kali river. This belt of sandy soil is very narrow in extent.

DRAINAGE:

The area is drained by the river Kali and Sengar which initially flow from north to south and further swings in south east direction.

KALI RIVER:

The river rises in Muzaffarnagar and passes through the district of Meerut and Bulandshahr and enters into Aligarh from its northern border. It takes a devious but generally south easterly course along the western and southern boarder of the Atrauli Tehsil, passing into Etah near the village of Barhari. The river is perenial but not navigable. Its volume is increased by the surplus water from the Ganga Canal, occasionally it rises in flood, doing much damage to the Khadir lands along its course. The water is used to some extent for irrigation but only in the Khadir or low land. The width of the river where it enters the district shrinks to some 10 m and depth to 0.91 m in the hot weather.

SENGAR:

Sengar is a tributary of Yamuna river. it drains through

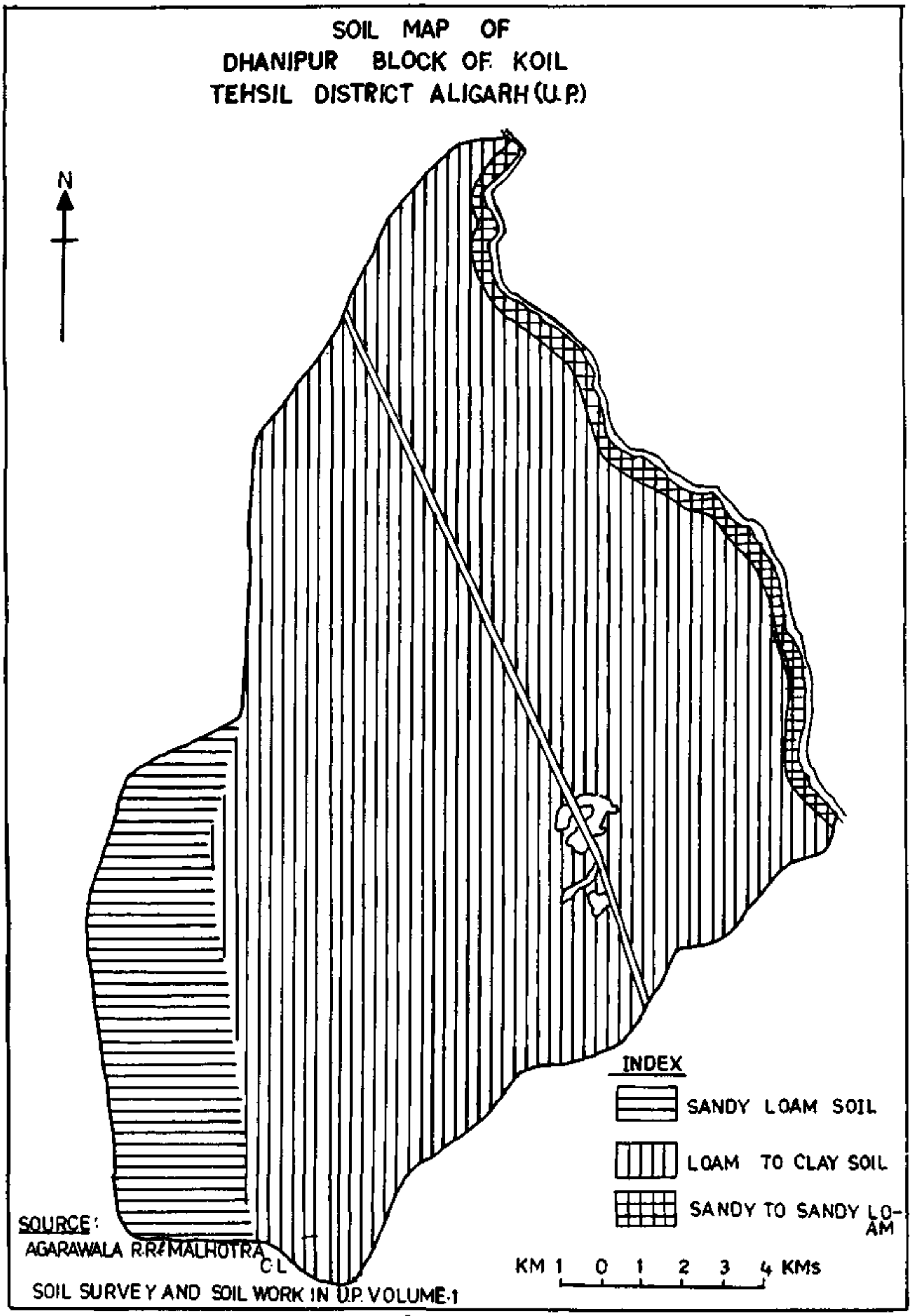

SOIL MAP OF
DHANIPUR BLOCK OF KOIL
TEHSIL DISTRICT ALIGARH (U.P.)
N
INDEX
SANDY LOAM SOIL
LOAM TO CLAY SOIL
SANDY TO SANDY LOAM
KM 1 0 1 2 3 4 KMs
SOURCE:
AGARAWALA R.R. & MALHOTRA C.L.
SOIL SURVEY AND SOIL WORK IN U.P. VOLUME-1

Fig.—2

the Central depression drawing water from numerous swamps. It springs from the great Awadhan lake to the south of Panethi on Grand Trunk Road. From Awadhan the Sengar flows almost due south through the south east corner of the Aligarh Tehsil and then after Barhad, Hathras continuing in the same direction till it quite the district at Nurpur. The Sengar remains practically dry during the summer but during rainy season it attains great dimension because it is the only stream which takes the total runoff of the Central depression. Its banks are sloping and in most places the bed is of softy clay.

## SOIL TYPE OF DHANIPUR BLOCK

The soil survey of the district was carried out by the Agricultural Department of Uttar Pradesh in 1953. In all three types of soils have been reported pertaining to the physiographic units of the block (Agarawala & Mehrotra 1953) (fig.– 2 ).

### 1. Sandy loam to loam:

It covers a small portion of the area along the coarse of Kali river. Above the Kali Khadir rises the high sandy bank of the river which merges into a rich tract of excellent loam. The soil varies in colour from light brown to deep brown and texture is sandy to good loam. The soils are more leached than the other soils. Calcareous nodules occur almost every where in the sub-soil. The pH ranges from 6.2 to 6.8 . They are well drained and the soil salinisation is rarely observed.

2. Loam to clayey loam:

The area, lying west to sandy tract along right bank of Kali river, which extends westward to Upper Ganga Canal, is a fine stretch of good consistent loam soil. It imperceptibly merges into clayey loam of Central depression. Soils are sticky and generally loam to clayey loam in texture. They are grey in colour calcareous concretions or Kankar are formed as a seperate horizon or intercalated within the clay bed.

The loam soil being semi-pervious allows seepage from the canal bed into shallow aquifers, causing water logging and soil salinization. Soil salinization were also observed in the area west of the Upper Ganga Canal where the soil is clayey loam. The sodium salt gets deposited on surface in the form of reh after the water is evoporated. The pH value of this soil ranges from 7 to 8 and above. Iron and alumina remains constant and magnesia is less throughout the area.

3. Sandy to sandy loam:

This soil type covers a small strip in the western part of the area. The soil is mature and brown to raddish brown in colour. The texture is sandy to sandy loam. Usually the soil surface down to a depth of 20 to 25 cm is well drained soil and contains loose loam that can be easily cultivated. The percentage of lime is very low and magnesia is equal to lime. There is no concretion in the soil. The pH ranges from 6.5 to 7.5 .

LAND USE PATTERN:

Statistics regarding the land use pattern in Dhanipur Block is given in the Table-I. Out of the total area of 29394 hectares 75.68% of the area is under cultivation of which about 68.39% sown more than once. Out of the total irrigated area 21494 ha, an area of 10288 ha. is irrigated through the ground water sources, and 11206 ha. is irrigated by the surface water sources. A very small area 58 ha is covered by the forest. However, a large part of the area lies as barren and unculturable waste:

## TABLE - 1

Land use pattern in Dhanipur Block of Koil Tehsil District Aligarh(U.P.) (in hectare)

| Study area | Area | Forest | Culturable Waste | Fallow land | Barren & unculturable use | Land under nonculturable use | Pastures | Land under misc. Groves | Net area sown | Area sown more than once |
|---|---|---|---|---|---|---|---|---|---|---|
| Dhanipur Block of Koil Tehsil District Aligarh (U.P.) | 29394 | 58 | 732 | 1659 | 1736 | 2771 | 103 | 91 | 37456 | 15212 |

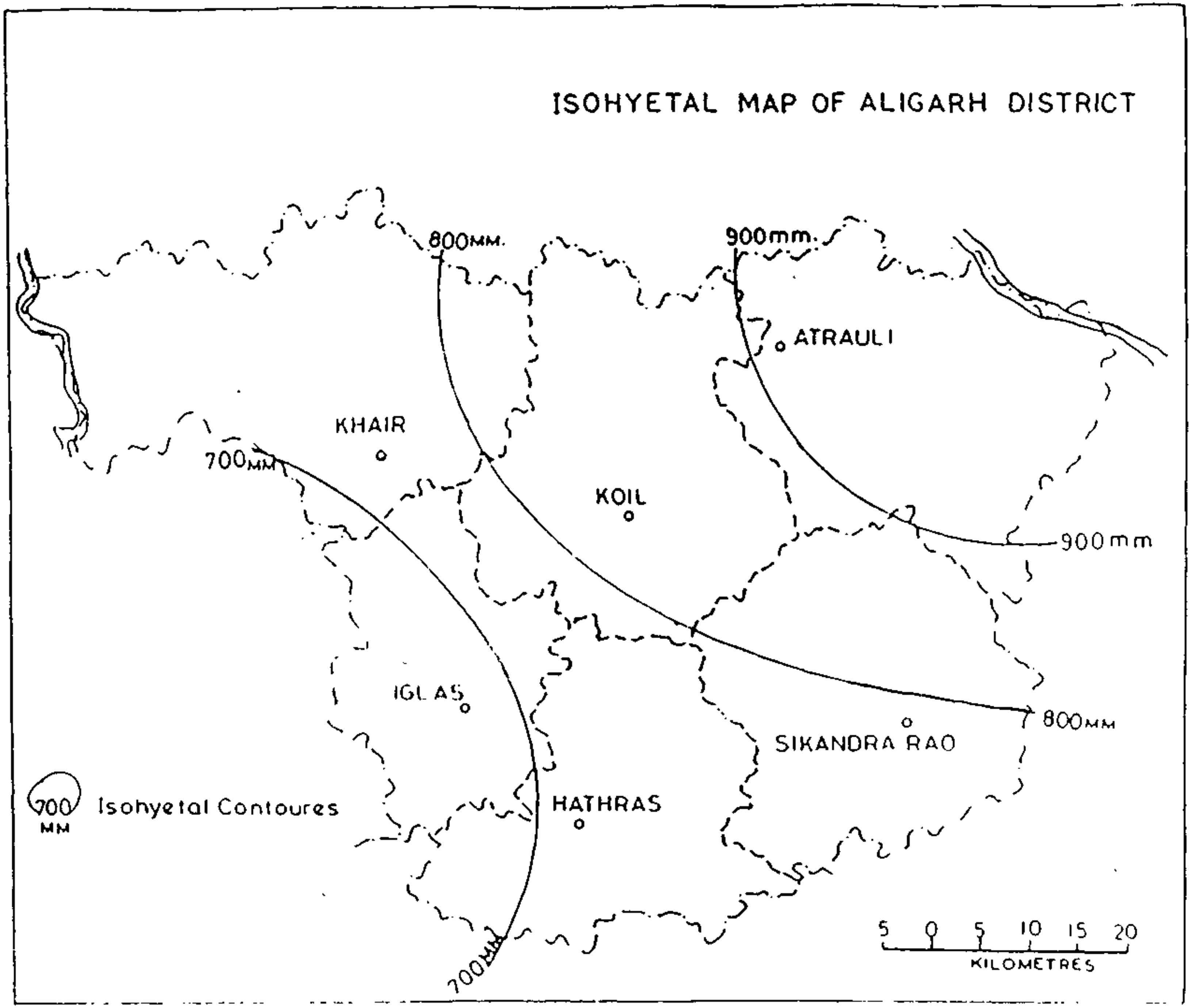

ISOHYETAL MAP OF ALIGARH DISTRICT
800MM.
900mm.
ATRAULI
KHAIR
700MM
KOIL
900mm
IGLAS
800MM
SIKANDRA RAO
700 MM
Isohyetal Contoures
HATHRAS
700MM
5 0 5 10 15 20
KILOMETRES

Fig.— 3

## CLIMATE AND RAINFALL

### CLIMATE:

Aligarh falls under subtropical climatic zone and is characterised by hot summer and chilly winter; summer starts around Middle March and continues till June with mean maximum temperature is 37°C, occasionally murcury shoots upto 46°C. During the winter season murcury touches 4°C.

### RAINFALL:

The monsoon normally breaks into second week of June and ends in September with an average rainfall of 760 mm. July and August are the months of heavy rainfall.

### AREAL DISTRIBUTION OF RAINFALL:

A persual of the isohyetal map (Fig. 3) of the district shows that the intensity of rainfall decreased from east to west. On an average the eastern part of the district receive slightly more than 900 mm annual rainfall which gradually decreases to 600 mm in west proximal to the river Yamuna.

DEPARTURE OF ANNUAL RAINFALL FROM MEAN ANNUAL RAINFALL

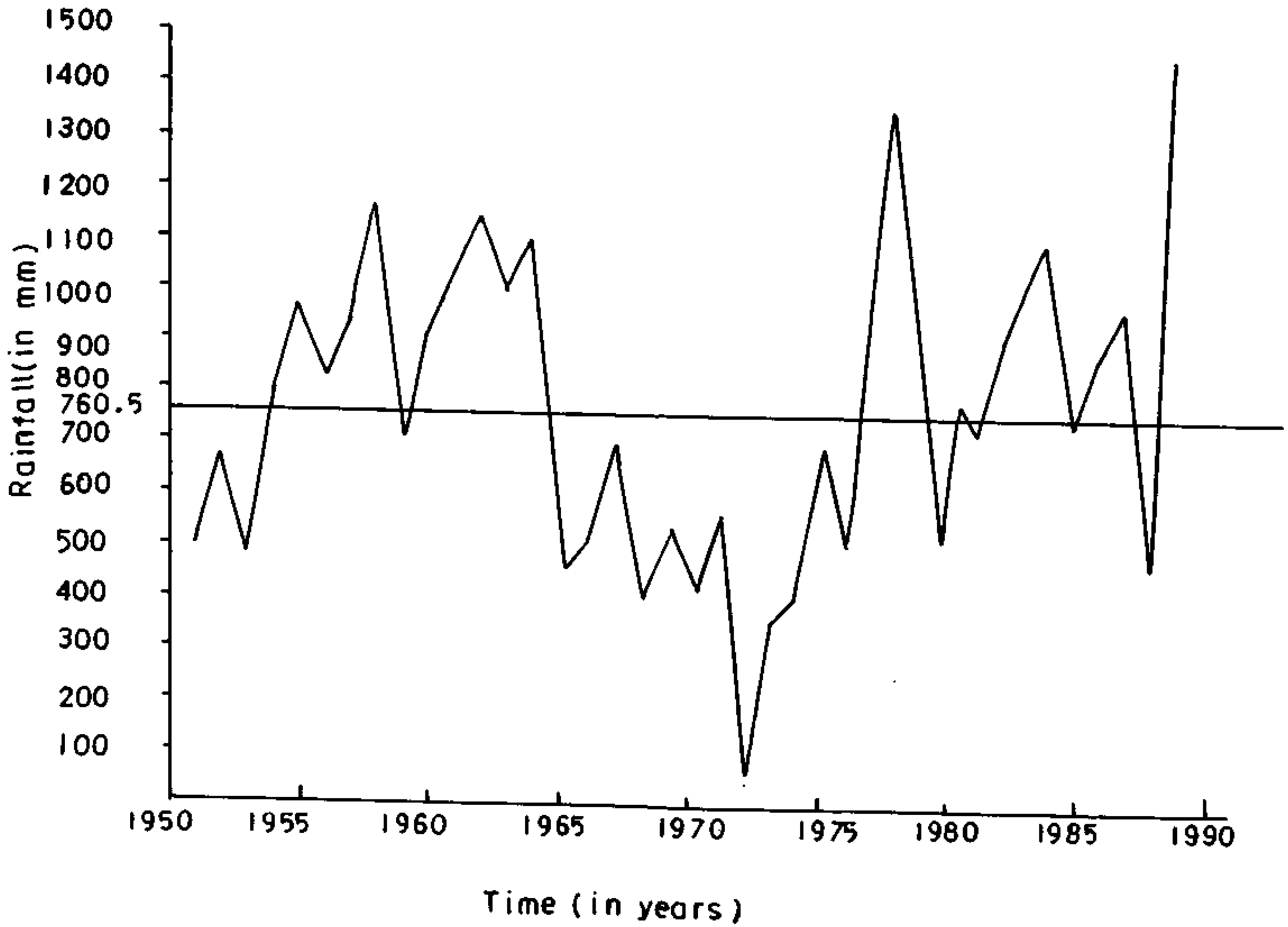



Fig.—4

T A B L E - 2

Result of statistical analysis of annual rainfall at Dhanipur Block of Koil, Tehsil district Aligarh.

| | |
|---|---|
| Highest rainfall (1988) | 1431.8 mm |
| Lowest rainfall (1972) | 69.8 mm |
| Mean | 760.5 mm |
| Standard Deviation | 297.2 |
| Coefficient of variation (%) | 39.1 |

VARIABILITY OF RAINFALL:

The available annual tainfall data of Aligarh for the period of 1950-1988 have been statistically analysed and results tabulated (Table - 2). It is seen that highest rainfall at Aligarh raingauge station is 1431.8 mm where as the lowest only 69.8 mm showing a very wide range (fig. 4).

The mean annual rainfall is 760 mm. The standard deviation is 297.2 and the coefficient of variation is 39%.

TABLE - 3

Results of Drought analysis at Aligarh

| Type of Drought | Year | Frequency of occurance |
|---|---|---|
| 1. Mild drought (0.0 to 25%) | 1952-1959, 1967 1975, 1981 | 13.2% |
| 2. Normal drought (25.1% to 50%) | 1953, 1957, 1965, 1966, 1968, 1969, 1970, 1971, 1974, 1979, 1989 | 29% |
| 3. Severe drought (50.1% to 75%) | 1973, 1987 | 5.3% |
| 4. Very severe drought (75.1 to 100%) | 1972 | 2.6% |

DROUGHT ANALYSIS:

Departure of annual rainfall from mean annual rainfall have been calculated for the Aligarh city rain gauge station. The calculated values of departures have been used in drought analysis (Table-3).

The study shows that there is no cyclicity as such. The frequency of occurance of mild to normal drought at Aligarh is 42.27% and the frequency of severe drought is 5.3%.

......

# C H A P T E R - III : <u>GEOLOGY</u>

# G E O L O G Y

The Block forms a part of Kali-Sengar Doab of the Central Ganga basin.

There are various views regarding the origin of the Indo-Gangetic plain.

It was interpreted to be a foredeep (Suess, 1904-1924); or a great rift valley (Burrard, 1915), filled up with alluvium of thickness 4.5 km (Old ham, 1917) to 20 km (Pascoe, 1964).

A more recent view regards it as a sag in the Crust. But at present it is generally accepted that the Ganga basin was formed as a result of buckling down of the northern fringe of the peninsular shield thrust over from north(Krishnan, 1968).

Valdiya (1982), interpreted it as a resultant effect of sagging of the northern flank of the platform around the Bundelkhand shield, following the main episode of the Himalayan orogeny. The depressed platform became the site of sedimentation by vigorous fluvial agencies predominantly from the newly risen Himalayas.

Recently, Indo-Gangetic plain is considered a peripheral fore land basin (Dickinson, 1974) formed as a result of continent-continent collision between India and Asian Plates.

The sub-surface topography of the Ganga basin comprising alternate ridges and depressions (Sastri et al , 1971; Rao 1973) are as follows:

1. Delhi - Hardwar ridge
2. Sarda depression
3. West U.P. shelf
4. Faizabad ridge
5. East U.P. shelf
6. Gandak depression

ALIGARH - KASGANJ TANAKPUR SPUR:

The spur marks the eastern limit of the Aravalli horst. Sarda river flows along this spur. The eastern edge of this spur coincides with the sub-surface extension of the Great Boundry Fault which seperates Aravalli rocks from that of the Upper Vindhyans.

The analytical study of the structural patter of the exposed foothills, gravity anamoly and the basement

SUBSURFACE GEOLOGICAL CROSS SECTION ALONG SALEEMPUR, ALIGARH, KASGANJ, UJHANI IN PARTS OF CENTRAL GANGA-BASIN

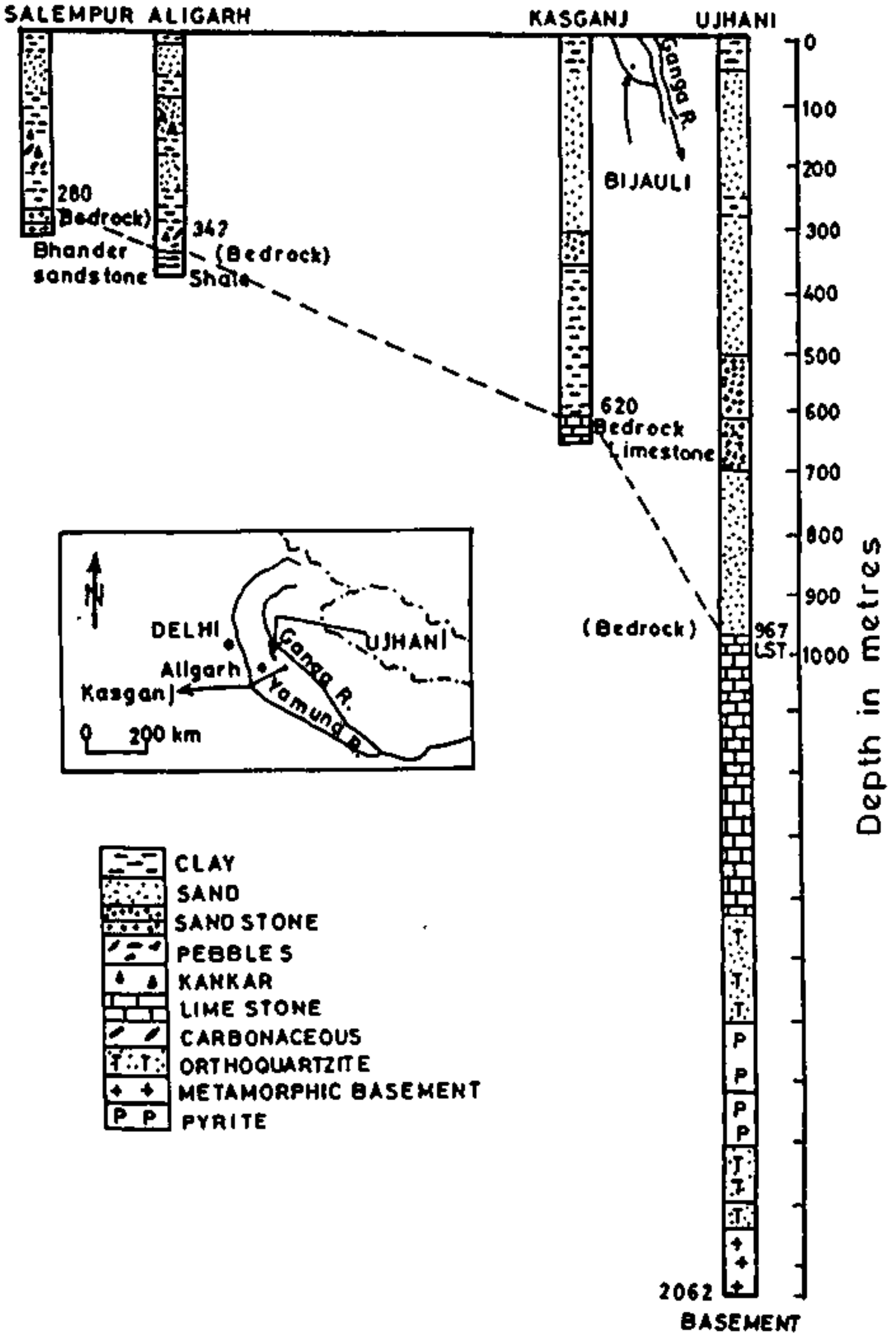



Fig. 5

contour maps of the plain reveal that the spurs are fault bound (O.N. G.C., 1983)

The study area lies on the Western flank of Aligarh Kasganj-Tanakpur spur and to the south of Ramganga depression.

SUB-SURFACE GEOLOGY OF THE AREA:

The geological corss-section drawn (fig-5) on the basin of the data of the deep wells drilled by O.N.G.C. at Kasganj and Ujhani and by C.G.W.B. at Saleempur and Aligarh reveals the sub-surface geology of the area. The bedrock encountered at Saleempur at a depth of 286.94 m. b.g.l. is Upper Bhander Sand Stone. In Aligarh the bedrock encountered at a depth of 340 m.b.g.l. is Upper Bhander red shale. The bedrock encountered at Kasganj and Ujhani at 620 and 967 m depth respectively, are brown Lower Bhander limestone.

On the eroded surface of the aforementioned Upper Vindhyan rocks, Quarternary sediments were deposited comprising alternate beds of clay and sand with occasional intercalations of Kanker.

The thickness of the alluvium increases due north-east. The alluvium constitutes an asymmetric prism of sediments with its axis of thickest deposition close to Himalayan foothills.

The maximum depth of the, water well drilled in the Dhanipur Block is 160 m.b.g.l. However, the deepest well drilled by C.G.W.B. close to Aligarh Railway Junction, the bedrock was touched at a depth of 340 m.b.g.l.

The geological sequence based on the drilling data of the above well is as follows:

| | | | |
|---|---|---|---|
| Quarternary | - | Alluvium-Alternate beds of clay and sand and occasionally intercalations of Kanker | 340 M |
| ---------------------Unconfirmity--------------------- | | | |
| Upper Vindhyan | - | Upper Bhander red shale (Sirbu shale) | |

# C H A P T E R - IV : HYDROGEOLOGY

- Ground water conditions
- Aquifer geometry
- Depth to water level
- Water level fluctuation
- Movements of ground water

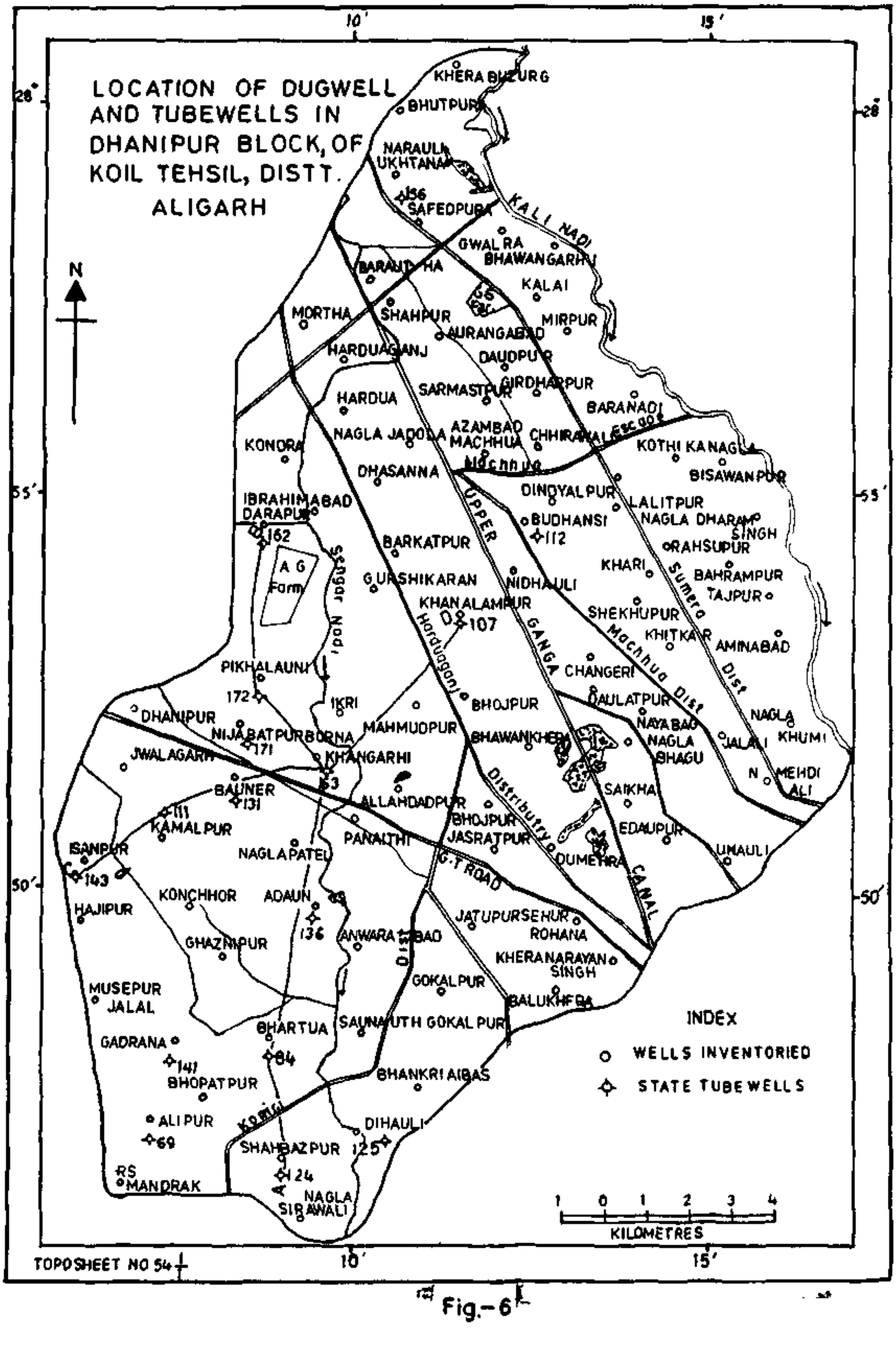

LOCATION OF DUGWELL AND TUBEWELLS IN DHANIPUR BLOCK, OF KOIL TEHSIL, DISTT. ALIGARH
N
INDEX
WELLS INVENTORIED
STATE TUBEWELLS
KILOMETRES
TOPOSHEET NO 54
KALI NADI
UPPER GANGA CANAL
G.T ROAD
A G Form
DHANIPUR
KHERA BUZURG
BHUTPUR
SAFEDPUR
HARDUAGANJ
MORTHA
SHAHPUR
AURANGABAD
KONORA
DHASANNA
IBRAHIMABAD
DARAPUR
BARKATPUR
BUDHANSI
NIDHAULI
KHANALAMPUR
PIKHALAUNI
BHOJPUR
JWALAGARH
BAUNER
KAMALPUR
ISANPUR
HAJIPUR
KONCHHOR
ADAUN
GHAZNIPUR
MUSEPUR JALAL
GADRANA
BHOPATPUR
ALIPUR
MANDRAK
BHARTUA
SHAHBAZPUR
DIHAULI
NAGLA SIRAWALI
BHANKRI AIBAS
GOKALPUR
BALUKHERA
UNAULI
EDAUPUR
SAIKHA
DAULATPUR
CHANGERI
SHEKHUPUR
AMINABAD
TAJPUR
BAHRAMPUR
LALITPUR
BISAWANPUR
KOTHI KANAGLA
BARANADI
GIRDHARPUR
MIRPUR
KALAI
GWALRA
BHAWANGARHI

Fig.-6

# H Y D R O G E O L O G Y

Hydrogeology plays an important role in the determining the water bearing, storing and transmitting capacity of geological formations. Systematic well inventories of 86 dug-wells and 11 tubewell (shallow and deep) were carried out and relevent hydrogeological data were collected to bring out valuable information pertaining to ground water conditions in the area.

Multidisciplinary studies in a basin or sub-basin are being carried out for the estimation of resource potential and detail analysis of various parametres. The above data collected were, thus utilized in the preparation of depth to water level maps (pre-monsoon and post-monsoon), water level fluctuation map and water table contour maps (pre-monsoon and post-monsoon), which bring out the potential area for further ground water development. Besides, the lithological logs of the bore-holes of the deep and shallow tubewells were studies and utilized to prepare the cross-section in order to depict the surface geology and aquifer disposition in the area. Location of dugwells and tubewells inventoried are shown in the figure-6.

## GROUND WATER CONDITIONS:

Ground water in the study area occurs both under pheratic and Semi-confined to confined conditions depending upon the absence or presence of aquaitard and aquiclude as confining beds. The shallow aquifers are pheratic in nature, where as deeper aquifers are semi-confined to confined in nature.

The rainfall is the main source of ground water recharge. The recharge also occurs through irrigation return flow and Seepage from the Upper Ganga Canal and its distributaries.

## EVOLUTION OF AQUIFERS:

The evolution of the aquifers in the fluvial system is dependent upon hydrodynamics of the flow regime, geology and topography of the terrain, leading to the terrigeneous clastic deposition system, which are typically represented as channel, flood plain and back swamp deposits.

### Channel deposits:

The typical channel deposits in the study area from bottom upward comprise medium to fine sand, occasionally mixed with coarse sand and gravel, and a very thin clay layer on the top. The top clay and some fine sand layers are washed away during successive flood seasons and a fresh body of sand with fining upward sequence is deposited each year, forming thereby a reasonably thick terrigeneous clastic deposits till the river changes its course due to some tectonic disturbances. The thick bodies of sand deposited as channel deposits form the areally extensive and highly potential aquifers.

<u>Flood Plain Deposits</u>:

During the flood season when the flood water overflows the banks, medium to fine sand bodies of limited areal extent and moderate thickness are deposited over the flood plain. These lenticular bodies of sand form moderately potential aquifers in comparison to the highly potential aquifers of the channel deposits. The lenticular shape of the aquifers is due to the fact that flooding takes place in a limited stretch of the river banks at a time.

<u>Backswamp Deposits</u>:

The flood water from the high banks further moves down the slope towards the low lying areas where it is left predominantly with the suspended materials only, which get settled under the influence of gravity and form a lensoid body of sand which is later on overlain by clayey horizon.

Thus, the lensoid sand bodies generated occur as intercalations within the thick bodies of clay. Such bodies of sand characterise the backswamp environment and form the poor aquifers, very often associated with the quality problem. The enclosed nature of such aquifers obstruct the regular flushing or recharge rendering thereby to poor quality formation of water.

Further, as the river changes its course, the position of the channel, flood plain and backswamp deposits also continue changing with the passage of time. This is the reason that no continuous body of sand or clay are found in a borehole except under the extraordinary geologic situations. Thus the lithological variations are attributed to their mode of deposition by the constantly shifting nature of the streams draining the area.

The various aquifer system, thus generated by the river Ganga and its tributaries like Sengar and Kali, are as follows:

(a) The channel deposits-the thick bodied aquifers of infinite areal extent, forming most potential groundwater reservoir.

(b) Flood plain deposits - the lenticular aquifers of limited

- LITHOLOGICAL CORRELATION OF THE BORE HOLE LOGS SHOWING AQUIFER DISPOSITION IN DHANIPUR BLOCK ALONG-AB

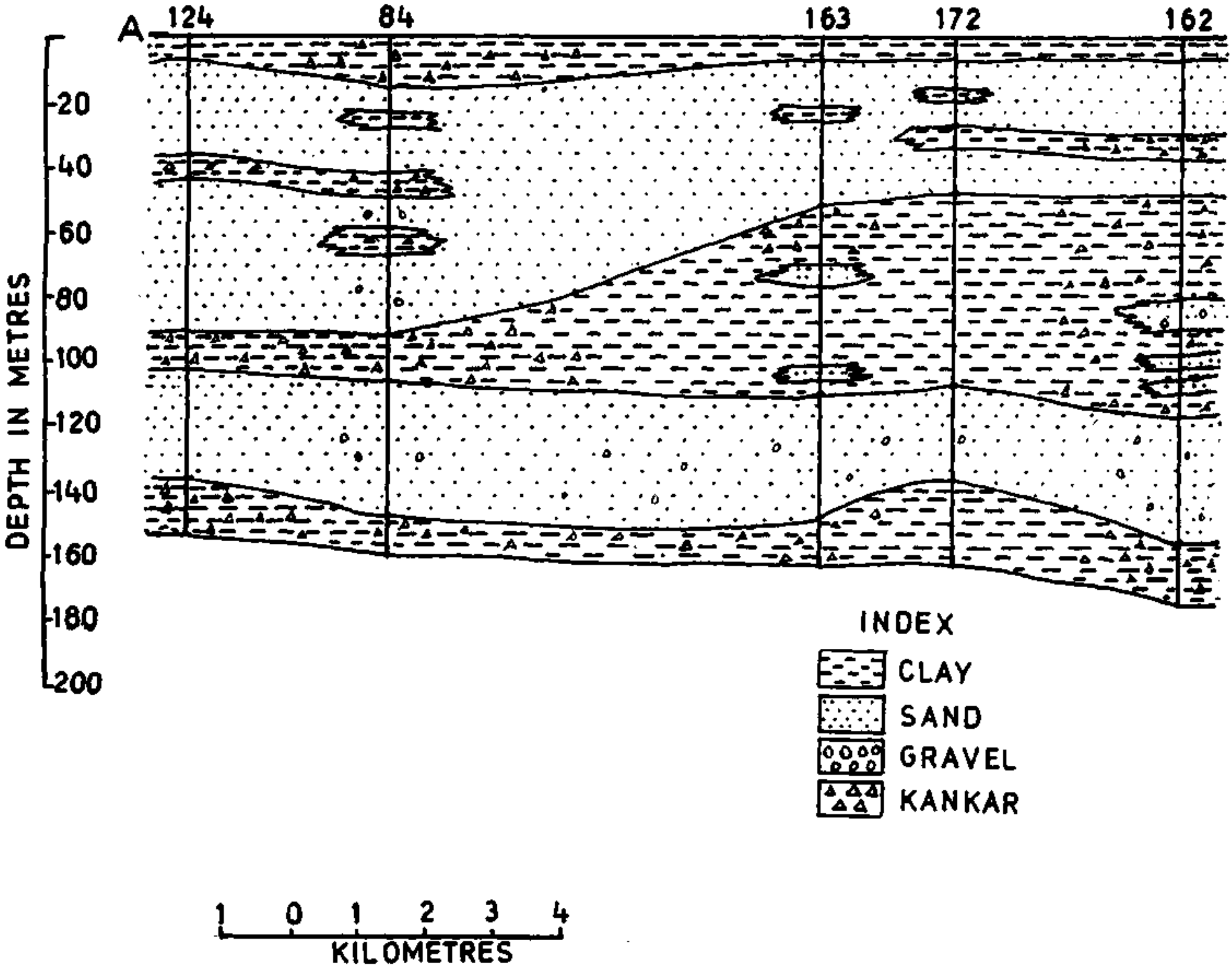



Fig —7

LITHOLOGICAL CORRELATION OF THE BORE HOLE LOGS SHOWING AQUIFER DISPOSITION IN DHANIPUR BLOCK ALONG-CD

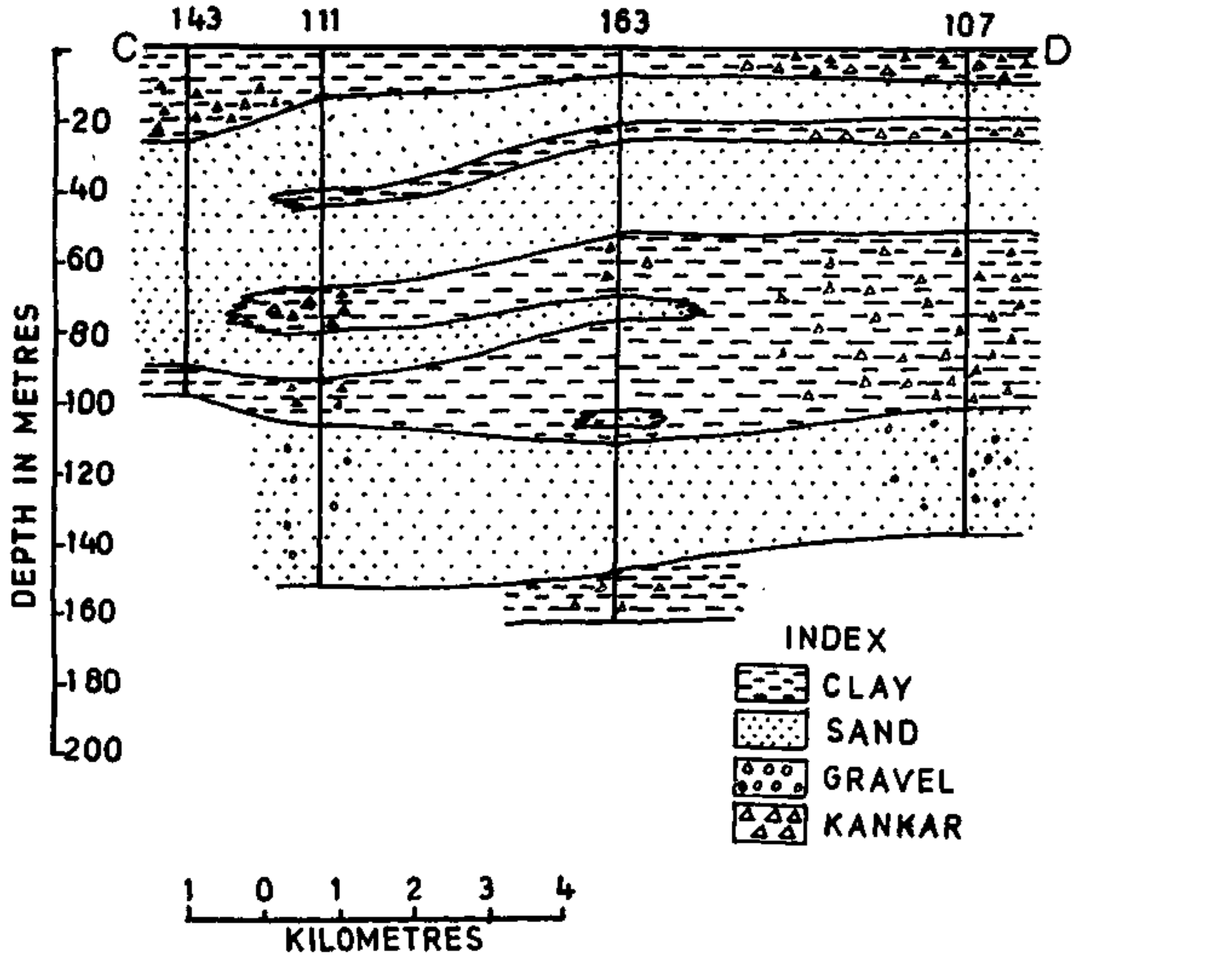



Fig-8

thickness and areal extent and only moderately potential.

(c) Backswamp deposits - the lensoid bodies of sand occuring as enclaves or stringers within the thick clay bed, generally forming the low potential aquifers with quality problems.

We find that in a thick Ganga alluvium, the complexes of the channel, flood plain or oxbow facies reappear several times in the wells drilled at places in the area. Thus the terrigeneous clastic depositional system of the river Ganga in the area of study is an index of its complex hydrodynamic regime which has generated various aquifers in the great Ganga plain.

AQUIFER GEOMETRY:

To ascertain sub-surface geological framework, borehole data of the state tubewells in Dhanipur Block were utilized and two geological cross-section namely A-B and C-D (fig 7 and 8) were prepared in order to delineat the various aquifers system their vertical and probable lateral extent in the area.

The study of the cross-sections show that there occurs two to three tier aquifer system in the block, down to 160 metres depth below ground level. By and large these aquifers appear to merge with each other and behave as single bodied aquifer system. The granular zones comprising medium to fine, grey micaceous sands, occasionally intermixed with coarse sands and gravel forms about 60 percent of the total formation encountered down to 160 m.b.g.l., in the central part of the area. The top clay with little kankar persist throughout the area, its thickness ranges from 6 to 21 m.b.g.l. Below it aquifers are encountered at depth range 12 to 70 m with an average of 50 m.b.g.l (first aquifer), 80 to 90 m.b.g.l (second aquifer) and 105 to 150 m.b.g.l (third aquifer). The upper most aquifer is extensive and highly potential, consist of fine to medium, grey micaceous sands, where as medium to coarse sands with quartz and kankar gravel comprise the second and third aquifers. The second aquifer is of limited areal extent and thickness (10 m) while third aquifer attains a sizable thickness of 40 m.

On the basis of the two geological cross-sections lithology of the boreholes and their hydrogeological properties, the aquifers occuring in the area can be described under two categories:

(a) Shallow aquifers occuring with the depth of 50 m.b.g.l.

(b) Deeper aquifers lying between 50 metres to 160 m.b.g.l.

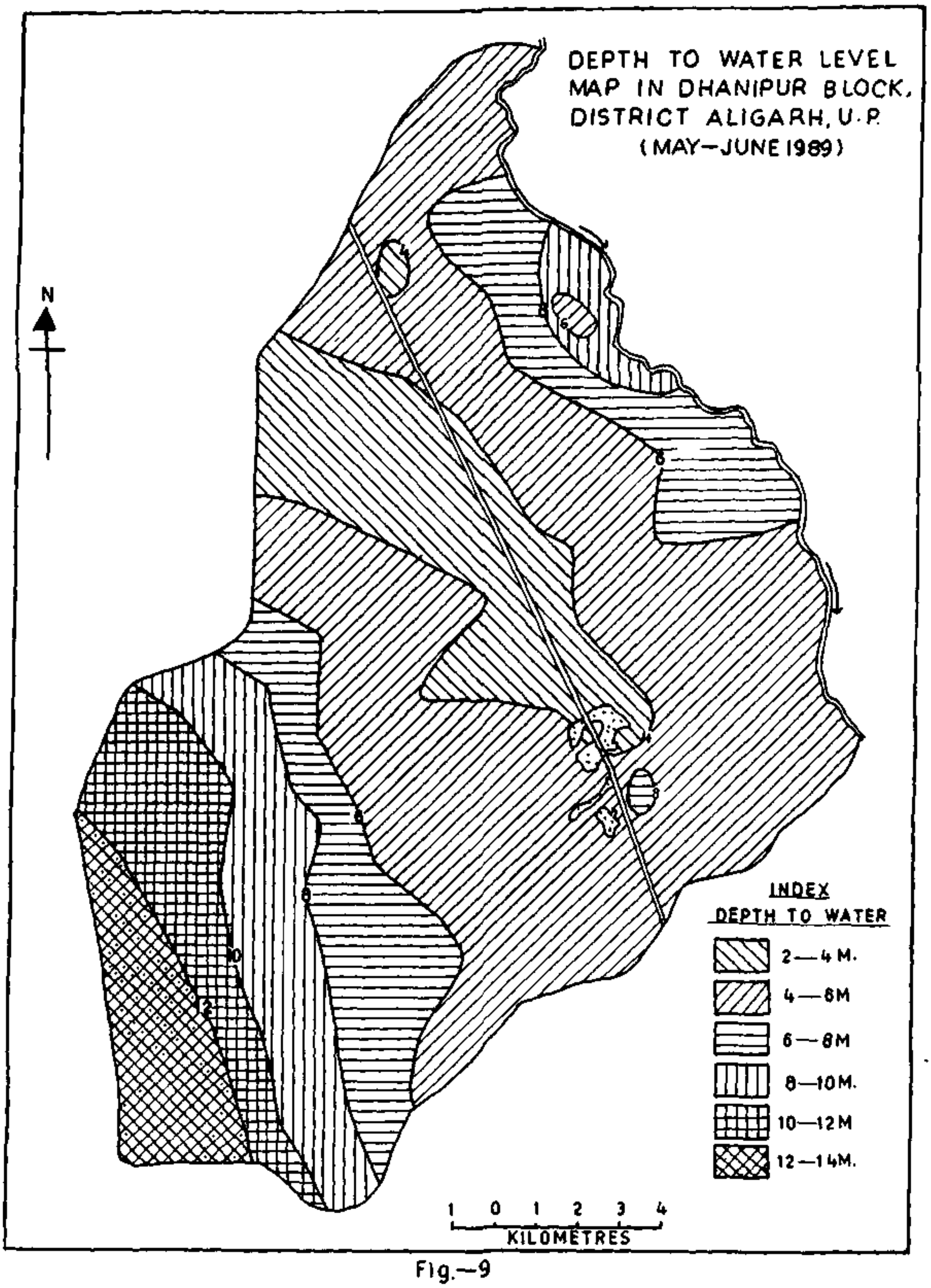

DEPTH TO WATER LEVEL
MAP IN DHANIPUR BLOCK,
DISTRICT ALIGARH, U.P.
(MAY-JUNE 1989)
N
INDEX
DEPTH TO WATER
2—4 M.
4—6M
6—8M
8—10M.
10—12M
12—14M.
1 0 1 2 3 4
KILOMETRES

Fig.—9

SHALLOW AQUIFERS:

The shallow aquifers occur within a depth of 50 metres from land surface, comprising mainly fine to medium sands. The aquifer thickness varies from 20 to 35 m.b.g.l. Groundwater in the aquifer zone occurs under water table to semi-confined conditions depending upon the thickness and composition of overlying clay beds. This top aquifer had been excessively developed through open wells, hand pumps and shallow tubewells mainly for domestic and irrigation purposes The general depth of the tubewells ranges between 18-25 m.b.g.l.

DEEPER AQUIFERS:

The deeper aquifers occur within a range of 50 to 160 m.b.g.l., comprising mainly medium to coarse sands often mixed with kankar gravels (fig - 7 & 8). The diagrams show that the ground water occurs under semi-confined to confined conditions and by the large they form an inter-connected aquifer system. As a whole there is a single body aquifer which is connected with each other and spread at different depth from ground surface. The deep tubewells generally tape aquifers occuring in the depth ranges of 100 - 160 m.b.g.l.

DEPTH TO WATER LEVEL:

The depth to water level map depicts the regional

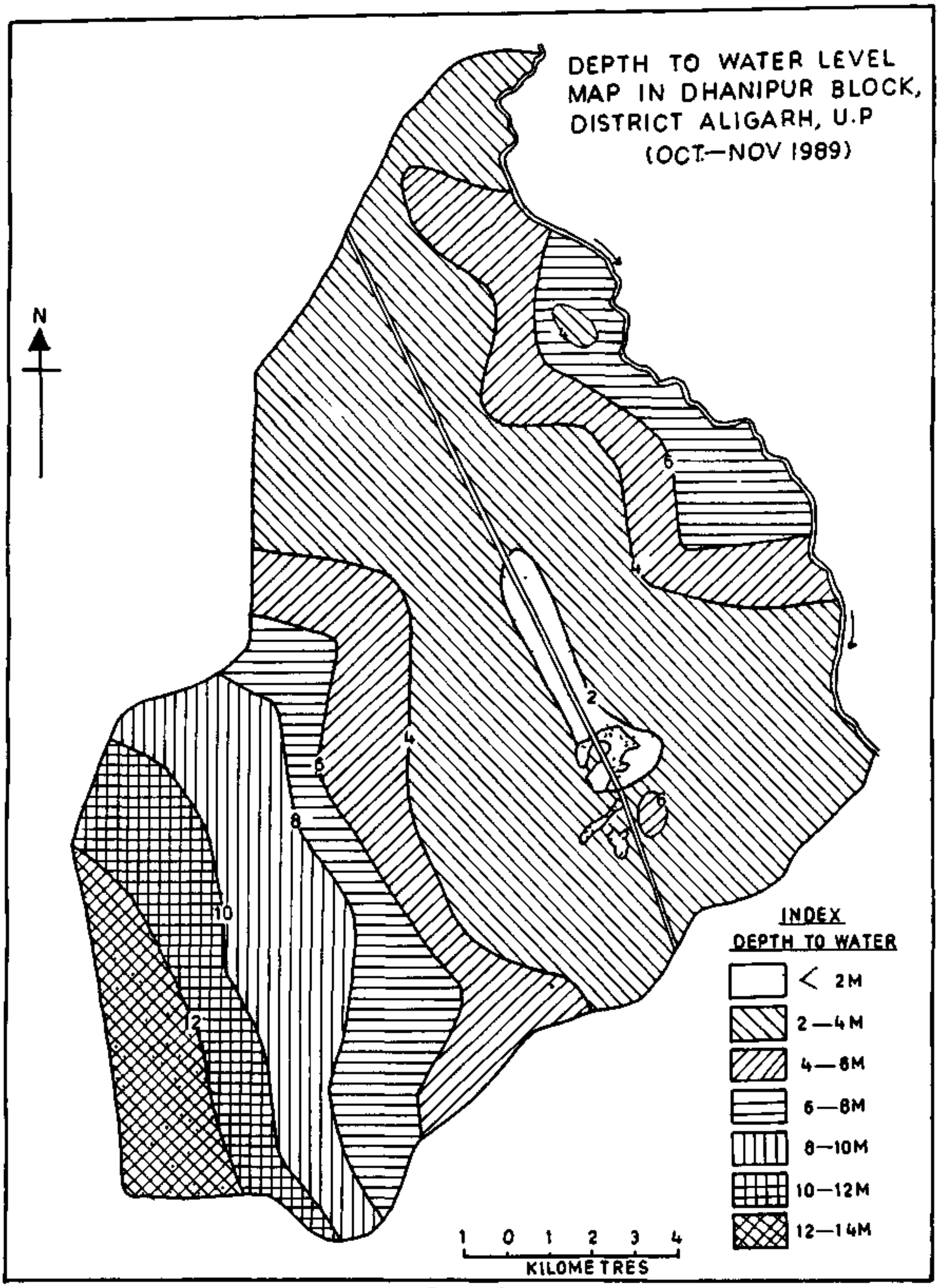

DEPTH TO WATER LEVEL
MAP IN DHANIPUR BLOCK,
DISTRICT ALIGARH, U.P
(OCT.—NOV 1989)
N
INDEX
DEPTH TO WATER
< 2M
2—4M
4—6M
6—8M
8—10M
10—12M
12—14M
1 0 1 2 3 4
KILOMETRES

Fig.—10

variation of water level below the ground level. The water level standing in dugwells are considered accurate enough to represent the water level of the area.

Based on the data collected, during May and November 1989, the pre and post monsoon depth to water level maps have been prepared (fig. 9 & 10). The pre-monsoon depth to water varies between 3.20 metres to 13.75 metres below ground level. The area in the vicinity of main canal and distributaries have the water level within 2 to 4 and 4 to 6 m.b.g.l. The depth to water level away from the canal are generally deeper. In the south western part of the area the water level is deeper which ranges between 12-14 m.b.g.l. The post-monsoon depth to water ranges between less than 2 (1.40) to 13.50 metres below ground level. Data in respect of these wells are given in appendix - 2.

WATER LEVEL FLUCTUATION:

Water level fluctuation map (fig - 11) of the area shows the difference in pre-monsoon and post-monsoon water levels. There are five distinct water level fluctuation zones viz (1) 0.5 m (2) 0.5 to 1 m (3) 1.0 to 1.5 m (4) 1.5 to 2 m (5) 2.0 to 2.5 m. In general the water level fluctuation is recorded between 0.5 to 2.5 m.

The water level fluctuation is a direct response of

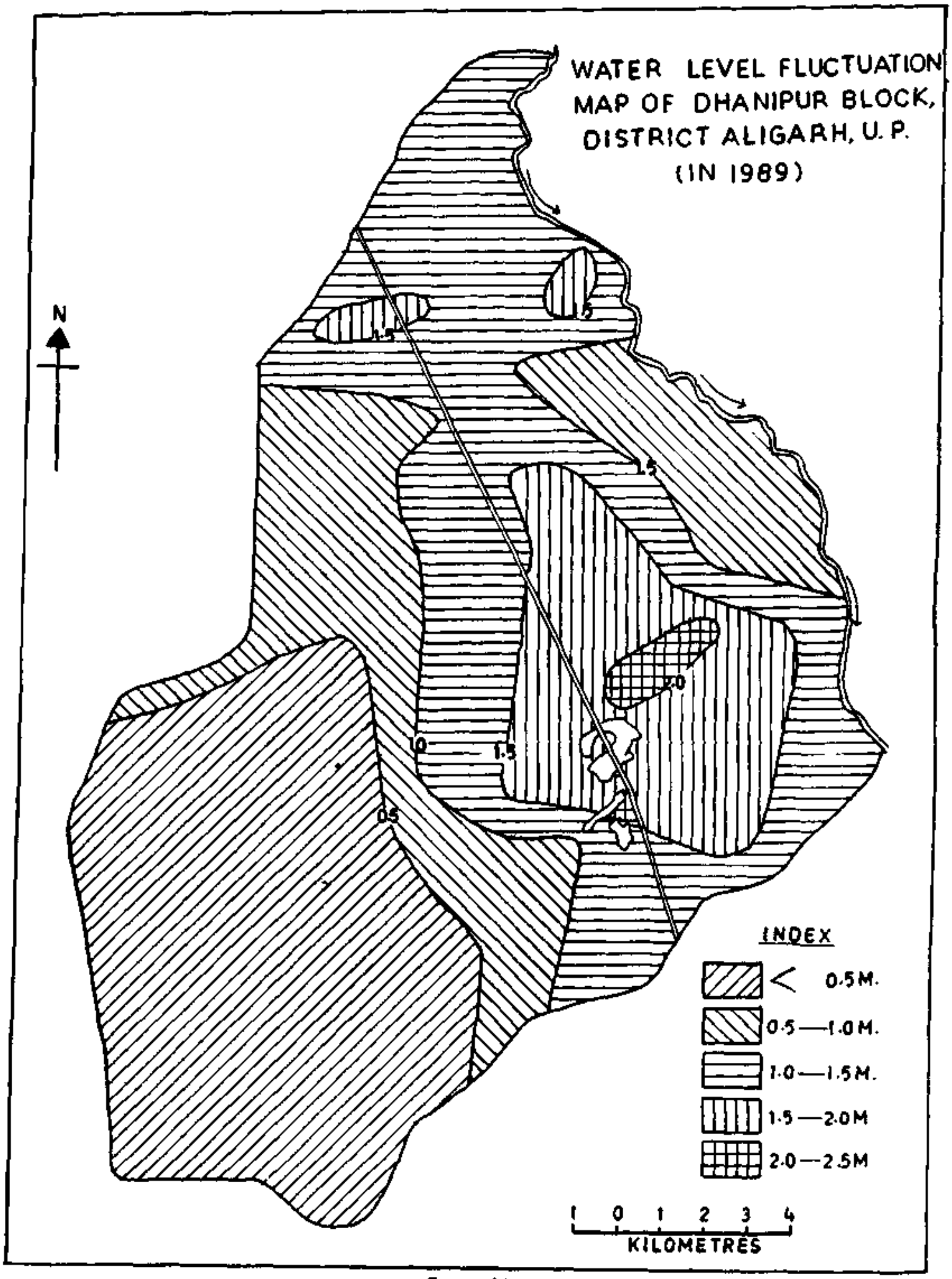

WATER LEVEL FLUCTUATION
MAP OF DHANIPUR BLOCK,
DISTRICT ALIGARH, U. P.
(IN 1989)
N
1.5
1.5
1.5
1.0
1.5
2.0
0.5
INDEX
< 0.5 M.
0.5 — 1.0 M.
1.0 — 1.5 M.
1.5 — 2.0 M
2.0 — 2.5 M
1 0 1 2 3 4
KILOMETRES

Fig.—11

of the ground water recharge and discharge in the area. Since rainfall is the main source of ground water recharge, so intensity, duration and distribution of rainfall are the controlling factors on ground water recharge. In addition, topography plays a vital role on the water level fluctuation, and quantum of recharge. It is common observation that the water table is deep in topographic highs and shallow towards the topographic lows, correspondingly, the annual fluctuation of water table is also deeper in the uplands and shallow in the depression, the amount of rainfall remaining the same in the area. The sub-surface outflow and inflow component of ground water makes this difference, while there would be sufficient space available for ground water inflitration and accumulation in the upland areas, shallow water table and water logged conditions in the lowlying areas leave space for ground water recharge.

MOVEMENT OF GROUND WATER:

Water level data of observation wells collected during May-June, 1989 and October - November, 1989 were analysed and the attitudes of the water level with reference to mean sea level were worked out. For this purpose all the observation wells were surveyed and connected with the survey of India Bench marks wherever available. The reduced levels of the water table with reference to the mean sea level were plotted on a map and a water table contour map was prepared with a contour interval

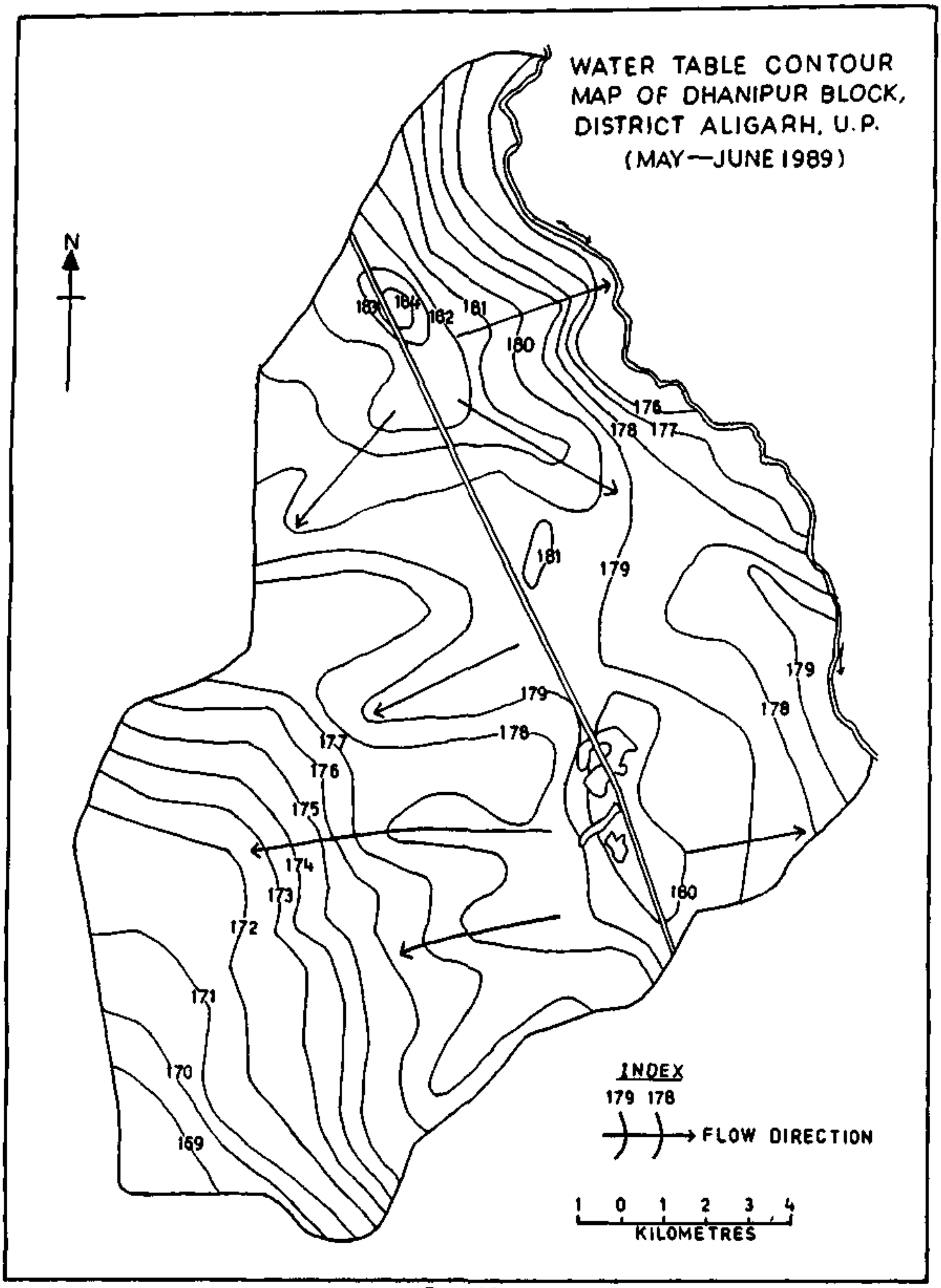

WATER TABLE CONTOUR MAP OF DHANIPUR BLOCK, DISTRICT ALIGARH, U.P.
(MAY—JUNE 1989)
N
183
184
182
181
180
176
178
177
181
179
179
178
179
178
177
176
175
174
173
172
171
170
169
180
INDEX
179 178
FLOW DIRECTION
1 0 1 2 3 4
KILOMETRES

Fig.-12

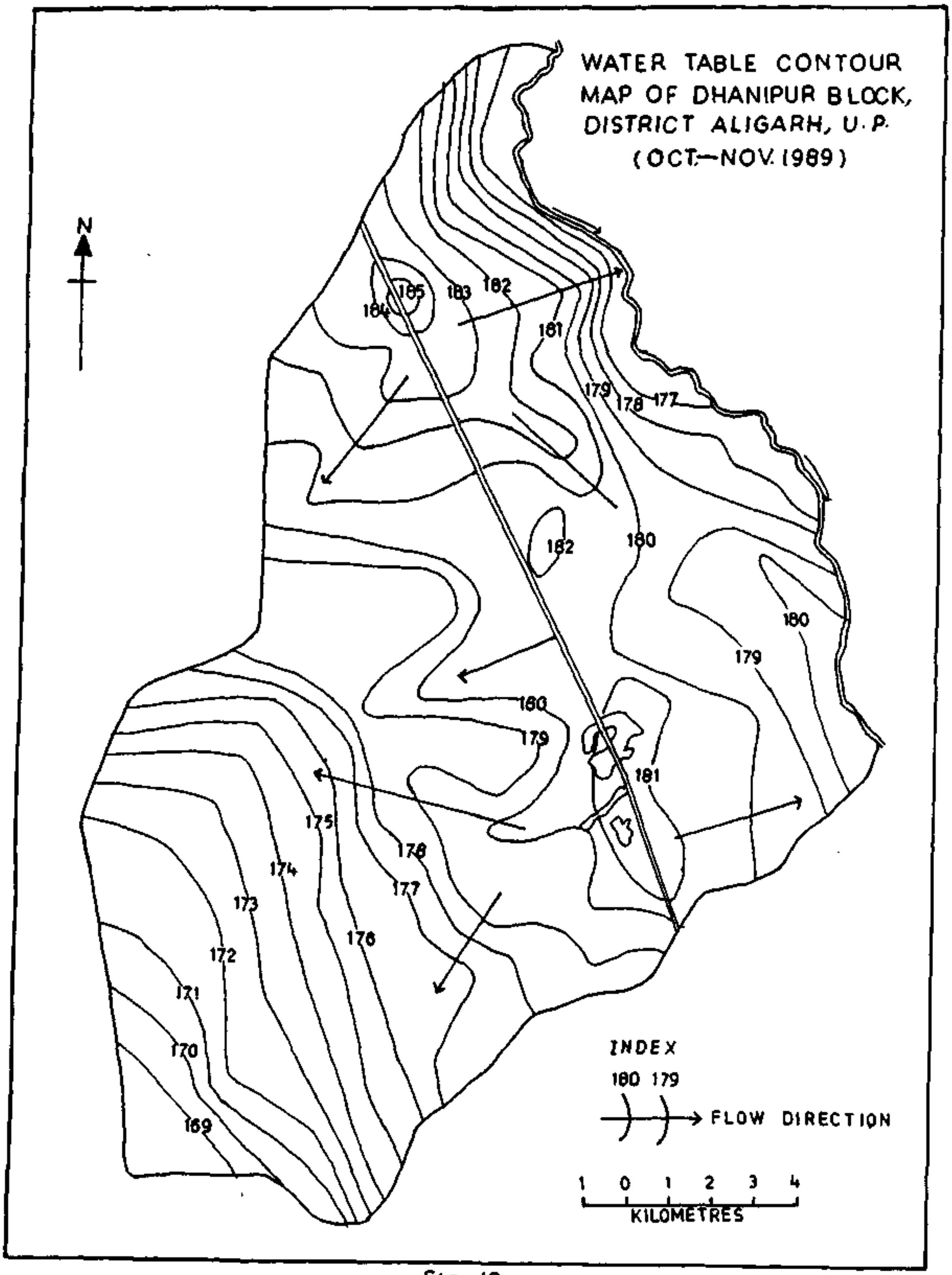

WATER TABLE CONTOUR
MAP OF DHANIPUR BLOCK,
DISTRICT ALIGARH, U.P.
(OCT.—NOV. 1989)
N
185
184
183
182
181
179
178
177
182
180
180
179
180
179
181
175
174
173
172
171
170
169
178
177
176
INDEX
180 179
FLOW DIRECTION
1 0 1 2 3 4
KILOMETRES

Fig.–13

of one metre (fig. 12 and 13).

The water table contour maps are used in deciphering the ground water flow direction hydraulic gradient, the area of recharge and discharge and the relation of ground water and the river. In such maps convex contours indicate the area of ground water recharge, while concave contours are associated with ground water discharge (Todd,1980).

The elevation of water table during pre-monsoon season ranges between 184.00 metres in the north west to 169.00 metres in the south west above the mean sea level.

The study of the water table contour map gives a clear picture of the ground water regimes. The Upper Ganga Canal passes through the upland area, which apparently makes the water devide. There are two mounds developed on northern and southern ends of the area around the canal. These mounds shed water in opposit direction. The ground water flow which is taking place towards east ultimately joins the Kali river, thereby indicating the effluent nature of the river. Water flowing towards west and south-west seems to join a ground water trough in the south-western part of the area. The mound which is developed around the canal in the southern part is also shedding water to Kali on the eastern side and to the trough

HYDROGRAPH OF PERMANENT NETWORK STATIONS
IN DHANIPUR BLOCK, DISTRICT ALIGARH, U.P.

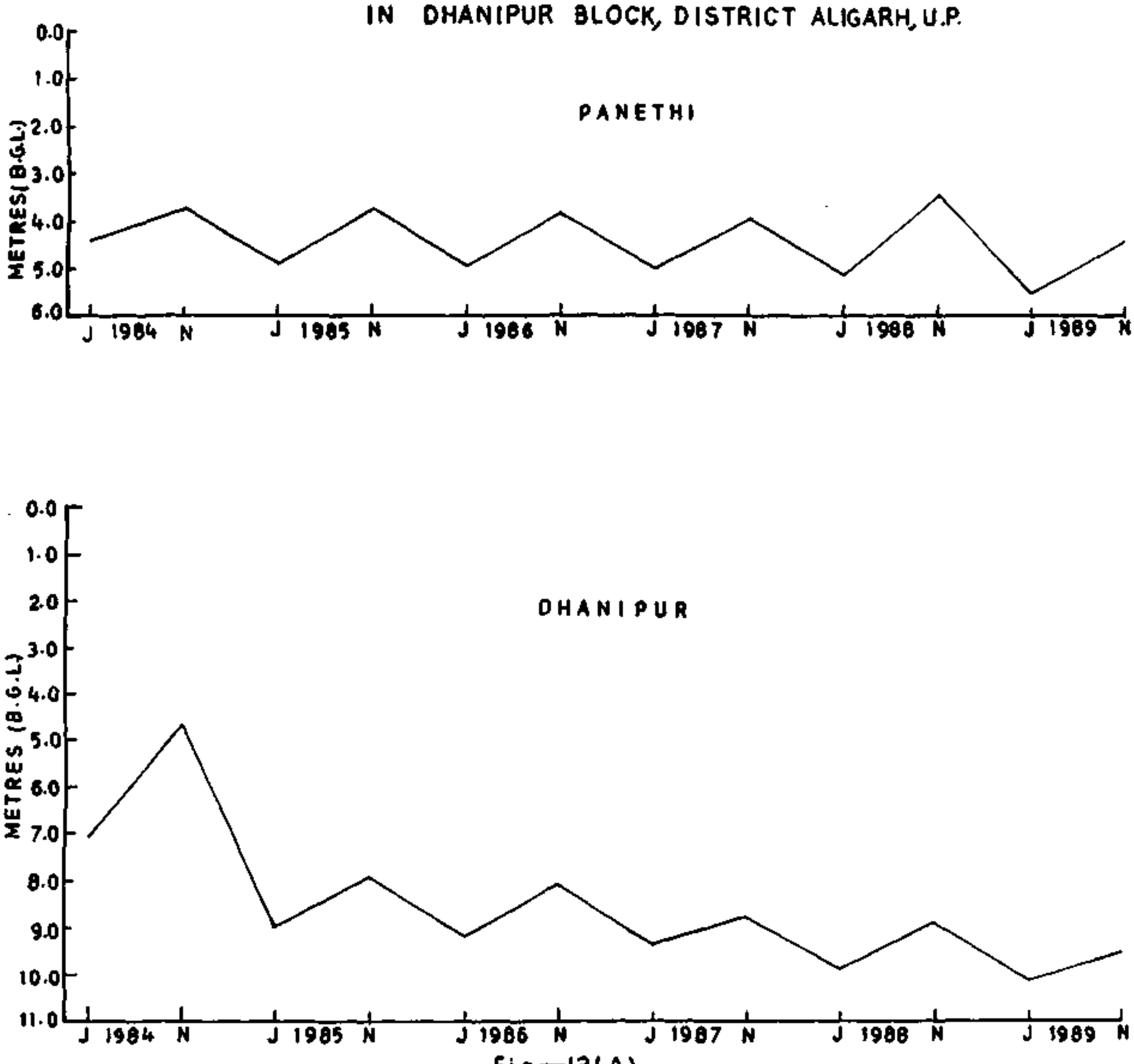



Fig.—13(A)

on the western side. In major part of the area the ground water flow is from north east to south west.

The general gradient of the area is 0.3 m/km. Along the Kali in the northern part of the area the gradient is considerably steep that is 2m/km, which is an indicative of thick clayey horizon. In the proximaties of Upper Ganga Canal, the contour spacing is wide, which shows the granular zones, thus making the potential aquifers.

The water table contour map for Oct-Nov., 1989 shows a similar pattern with the difference that the elevation of water table ranges between 185.00 metres in the north west and 169.00 metres in the south west above the mean sea level.

GROUND WATER BEHAVIOUR:

Hydrographs:

In order to study the ground water behaviour with respect to time and space, the water levels of key observation wells are used to prepare the hydrographs of the well. The hydrographs of the two wells for the period of 1984 to 1989 are shown in figure 13(A). A perusal of hydrographs indicate that the water level variation is cyclic, showing the deepest water level during the month of June and shallowest during the month of November. The water level starts rising by the end of June and attains the shallowest level in November. There is a sharp decline in the water level after November till January. From January onward the recession in water level in slow, which indicates natural ground water discharge through steady sub-surface outflow, in consonanace with regional ground water movement.

The rate of decline since 1984 to 1989 has been computed as .5 metre in Dhanipur and .2 metre in Panethi per year. This is mainly due to the fact that the ground water is the only source of irrigation in the western part of the study area as well as in Aligarh city with its 7 laks population where the ground water is the only source of water supply. The trend may aggravate in future due to increase in population, up coming of new colonies, extensive agricultural activities and excalating industrialisation in the western part of the study area.

.........

# C H A P T E R - V : <u>GROUND WATER BALANCE</u>

- Ground water recharge
- Ground water draft
- Stage of ground water development

# G R O U N D  W A T E R  B A L A N C E

Water balance study means the book keeping of water of a basin or region in relation to the components of the entire hydrologic cycle or part of it, done over a specific period (Chandra S. 1984).

Ground water development activity has increased considerably during the last few decades. This development has taken place indiscreminately without regards to the annual replenishment. The ground water potential of the basin must be evaluated to regulate the withdrawl of water from any basin. The ground water level of the ground water reservoir fluctuates according to inputs to it and withdrwal from it. A component wise estimation of input and output has to be evaluated using the available data of rainfall, irrigation application or other recharge components, withdrwal by wells and water table fluctuations. The evapotranspiration component is most difficult to evaluate and reasonable estimate is arrived at by suitable estimation of ground water resources, must be available for reasonably long period, but in any case for two years, and water balance approach used for evaluation.

Ground water is a replenishable resource, refined quantitative answers are needed for drawing up plans for its utilisation, management and conservation. In large scale injudicious exploitation of ground water resources has led to a decling trend of water levels in some areas and excessive surface water irrigation has caused water logging condition in the canal command areas. This has necessitated the evolving of a realistic approach for quick appraisal of available ground water resources of an area. Under the circumstances, the situation necessitates the prcise evaluation of ground water resources in a reasonably manageable area of limited extent.

GROUNDWATER RECHARGE:

Evaluation of ground water recharge parameter forms an important aspect of ground water resources evaluation It involves hydrometeorological, hydrological process taking place on the surface and also involves complex Sub-surface lithological characteristics. The major source of ground water recharge in the study area are as follows:

1. Recharge through rainfall
2. Recharge through canal seepage
3. Recharge through irrigation return flow

There are various methods to estimate ground water recharge viz. (i) water balance method (ii) seasonal fluctuation and specific yield method. In view of the prevailing irrigation pattern in the study area, the seepage losses to the aquifer will be very significant, hence the estimation by seasonal fluctuation and specific yield has been adopted for the evaluation of ground water recharge.

GROUND WATER RECHARGE BY SPECIFIC YIELD METHOD:

Recharge area = 293.94 Sq. km.

Average fluctuation = 1.2 m

Average specific yield = 15%

Groundwater recharge = Area involved x specific yield x water level fluctuation

= 293.94 x 1.2 x 0.15

= 52.9092 M.C.M. (Million Cubic Meters)

RECHARGE THROUGH IRRIGATION RETURN FLOW:

Total draft = 26.8576 M.C.M.

Infiltration factor = 15%

Groundwater recharge = $26.8576 \times \frac{15}{100}$

= 4.02864 M.C.M.

Groundwater recharge from surface water

= $6.24 \times \frac{15}{100}$

= 0.936 M.C.M.

Total Irrigation return flow = 4.02864 + 0.936

= 4.96464 M.C.M.

QUANTUM OF RECHARGE DUE TO CANAL SEEPAGE:

The seepage losses from the canal have been estimated by using the following emperical formula given by (Sehgal, 1973).

$$K = 4\ Q^{0.0625}$$

Where $K$ = Seepage loss factor

$Q$ = Canal discharge in cumes.

Seepage from upper Ganga Canal-

$Q = 227 \times 0.0283$

$= 6.4241$ Cumes

$K = 4(6.4241)^{0.0625} \quad = 4.4931$

Total seepage from canal = 4.4931 M.C.M.

Gross groundwater recharge $= 52.9092 + 4.96464 + 4.4931$

$= 62.36694$

70% of the gross recharge obtained as above is taken as recoverable recharge in the area.

$$62.36694 \times \frac{70}{100}$$

$$= 43.656858 \text{ M.C.M.}$$

GROUNDWATER DRAFT:

Groundwater is being tapped through open wells, handpumps, persian wells, shallow tubewells, and deep state and private tubewells. The unit draft of these ground water structure have been estimated by G.W.I.O. in this area which has been taken into consideration in evaluation of draft.

a) <u>DRAFT BY STATE TUBEWELLS</u>:

Unit draft of state tubewell = 0.175 M.C.M.

Number of tubewell = 39

Total draft = Unit draft x No. of tubewell

= 0.175 x 39

= 6.825 M.C.M.

b) <u>DRAFT BY SHALLOW TUBEWELLS</u>:

Unit draft of shallow tubewell= 0.0105 M.C.M.

Number of shallow tubewell = 1178

Total draft = Unit draft No. of shallow tubewell

= 0.0105 x 1178

= 12.369 M.C.M.

c) <u>DRAFT BY PRIVATE SHALLOW TUBEWELLS</u>:

Unit draft of private shallow tubewell = 0.0068 M.C.M.

Number of private shallow tubewell = 1062

Total draft = Unit draft x No. of private shallow tubewell

= 0.0068 x 1062

= 7.2216 M.C.M.

d) <u>DRAFT BY HAND PUMPS</u>:

| | | |
|---|---|---|
| Unit draft of hand pump | = | 0.00036 M.C.M. |
| Number of hand pump | = | 7000 |
| Total draft | = | Unit draft x No.of handpu |
| | = | 7000 x 0.000036 |
| | = | 0.252 M.C.M. |

e) <u>DRAFT BY DUG WELLS</u>:

| | | |
|---|---|---|
| Unit draft of Dug well | = | 0.00036 M.C.M. |
| Number of dug well | = | 500 |

Draft = Unit draft x Number of Dugwell

| | | |
|---|---|---|
| | = | 0.00036 x 500 |
| | = | 0.18 M.C.M. |

f) <u>DRAFT BY RAHETS</u>:

| | | |
|---|---|---|
| Unit draft of Rahet | = | 0.005 M.C.M. |
| Number of Rahet | = | 2 |

Draft = Unit draft x No. of Rahet

| | | |
|---|---|---|
| | = | 0.005 x 2 |
| | = | 0.01 M.C.M. |

TOTAL DRAFT= 6.825 + 12.369 + 7.2216 + 0.252 + 0.18 + 0.01 M.C.M.

= 26.8576 M.C.M.

The hydrological equation, which is basically a statement of the law of conservation of matter as applied by hydrologic cycle helps to define the water balance. It states that in specific period of time all water entering a specific areas must equal the water leaving the area plus/minus change in storage within the area. In case of groundwater system the water balance in its simplest form may be expressed as:

Groundwater balance $I - O = \pm \Delta S$

Where I = inflow

O = outflow

$\pm \Delta S$ = change in storage

43.6569 - 26.8576 M.C.M. = 16.7993 M.C.M.

$+\Delta S$ = 16.7993 M.C.M.

T A B L E - 4

Estimation of groundwater balance available for future development in Dhanipur Block of Koil Tehsil, District Aligarh.

| Area of Dhanipur Block | Gross recharge in MCM | Usable resource in MCM | 20% provision for domestic& industrial uses | Net resource available for irrigation MCM | Ground water draft on 1989 in MCM | Available for future development in MCM |
|---|---|---|---|---|---|---|
| 293.94 | 62.36694 | 43.6569 | 8.73138 | 34.92552 | 26.8576 | 8.06792 |

STAGE OF GROUNDWATER DEVELOPMENT:

Stage of groundwater development

$$= \frac{\text{Net yearly draft}}{\text{Net recoverable recharge}} \times 100$$

$$= \frac{26.8576}{43.6569} \times 100 = 61.51\%$$

In Dhanipur Block 61.51% groundwater resource has been developed and it falls in 'white' category with a considerable scope for further development in the area.

The study shows that the ground water development in Dhanipur Block is being done on large scale through the shallow farmer's tube wells. The assured irrigation through groundwater has revolutionised the food production in the Block which very well testifies its role in transfering the rural land scape and the economy of the people in the area. High yielding varieties crops like paddy & wheat & also vegetable need assured irrigation in time. Surface water is also available but it is not assured irrigation due to the lack in management and political exploitation. It creat, water logging near the main canal while the water could not reach in the field through the distrubutaries away from the main canal. So the farmers need their own shallow tubewells for irrigation. As the data shows that groundwater resource is available for irrigation. So the government should manage more shallow tubewells for the farmers for irrigation to increas the food grain production in this area.

## C H A P T E R - VI : HYDROCHEMISTRY

- Method of collection
- Analytical procedure
- Major elements and radicals
- Trace elements
- Water quality for domestic and municpal uses
- Water quality of irrigation purposes

# H Y D R O C H E M I S T R Y

In order to study the ground water quality, in all 37 ground water samples were collected during May-June, 1989 from open wells spread over the entire study area. The water samples collected were put to partial and complete chemical analyses in the Geochemical Laboratory of the Geology Department, A.M.U., Aligarh.

## METHOD OF COLLECTION:

The samples for partial chemical analyses were collected in well cleaned and treated one Litre capacity double stoppered polythene bottles. The bottles after collection of samples were capped with inner lid and then capped and sealed with wax instantly in the field. Another group of samples for trace elements studies were collected from selected observation station in seperate 2 Litre polythene bottles. This group of samples were treated at the site immediately with 10 ml 6 N $HNO_3$ and then capped and sealed with wax as above.

## ANALYTICAL PROCEDURE:

The samples for detailed chemical analyses(major and minor constituents) were analysed in the Geochemical

Laboratory of the Geology Department, Aligarh Muslim University, Aligarh as per standard methods recommended by APHA (1975), Jackson, M.L. (1958) and Trivedy and Goel (1984), and those collected for trace element determination were analysed in the same Laboratory by GBC - 902 Double Beam Absorption Spectrophotometer(Australia).

The samples were first analysed for major elements like sodium, potassium, calcium, magnesium and chloride and radicals like sulphate, carbonate, bicarbonate and for trace elements like iron, magnese, copper, zinc, nickel, cobalt, lead cadmium, chromium, lithium, rubidium, barium and strontium. Both anions and cations were determined by volumetric techniques except sodium, potassium and sulphate. Sulphate was determined by gravimetric method and sodium and potassium were determined by Atomic Absorption Spectrophotometer. The trace elements were determined with the help of Atomic Absorption Spectrophotometer. A blank sample was made for each spectrophotometric analysis in order to account for any analytical and instrumental error.

MAJOR ELEMENTS AND CADICALS:

1. **Hydrogen Ion Concentration (pH):**

Generally the shallow ground water in the area is

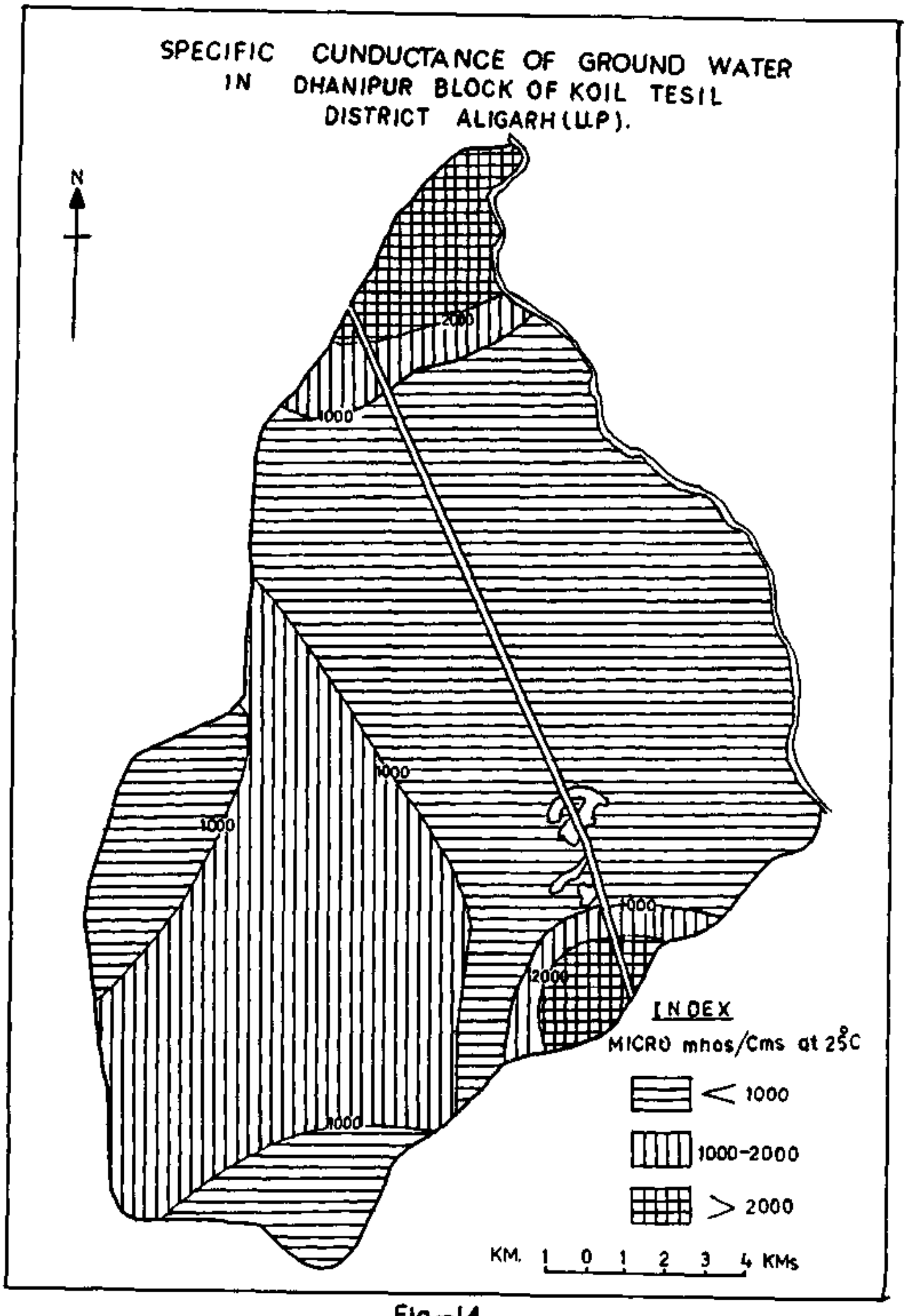

SPECIFIC CUNDUCTANCE OF GROUND WATER
IN DHANIPUR BLOCK OF KOIL TESIL
DISTRICT ALIGARH (U.P).
N
2000
1000
1000
1000
1000
2000
1000
INDEX
MICRO mhos/Cms at 25°C
< 1000
1000-2000
> 2000
KM. 1 0 1 2 3 4 KMs

Fig.-14

moderately alkaline in reaction with the pH value varying from 6.93 to 8.08. The highest value (8.08) of pH was recorded in the water sample of Nayabas. The pH of water is within the permissible limits for potable water.

2. **Electrical conductivity** (E.C. micromhos/cmat 25°C)

Electrical conductivity is the measure of the mineralisation and is indicative of the salinity of ground water. The specific conductivity values vary between 324 to 2460 micromhos/cm at 25°C. The sample of ground water of Ukhlana shows a high conductance value of 2460 micromhos. A persual of specific conductane map (Fig-14)indicates that more than 60% of the total area lies(at 25°C)below 1000micromhos/cm .

3. **Carbonates:**

The concentration of carbonate ranges from 6 ppm to 270 ppm. The lowestvalue is recorded in ground water samples of Rashupur, Edalpur and Bhudansi and the highest value is recorded in ground water samples of Ukhlana.

4. **Bicarbonate:**

Bicarbonate concentration varies from 299 ppm to 1202 ppm. The highest value is recorded in ground water

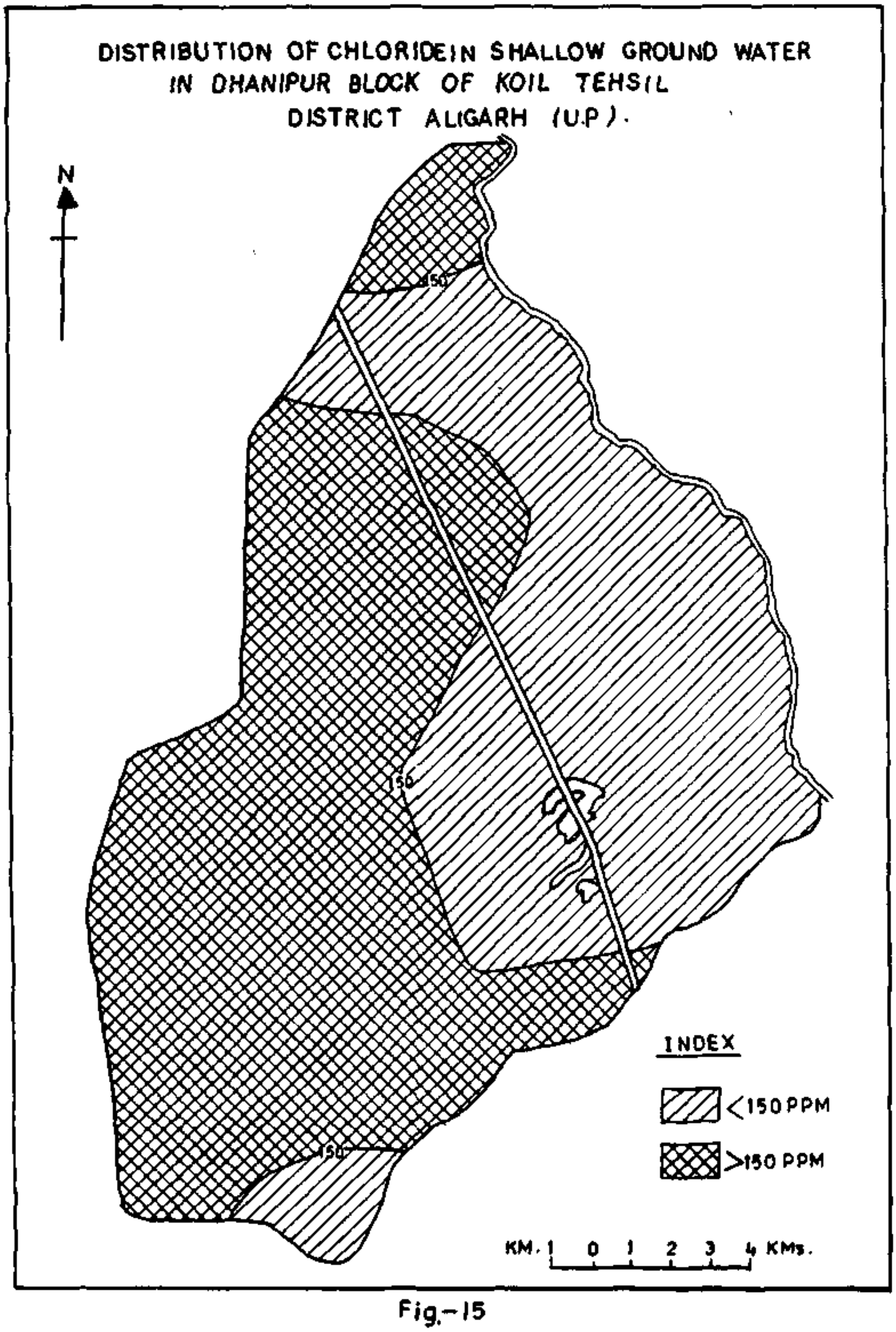

DISTRIBUTION OF CHLORIDE IN SHALLOW GROUND WATER
IN DHANIPUR BLOCK OF KOIL TEHSIL
DISTRICT ALIGARH (U.P).
N
150
150
150
INDEX
<150 PPM
>150 PPM
KM. 1 0 1 2 3 4 KMs.

Fig.-15

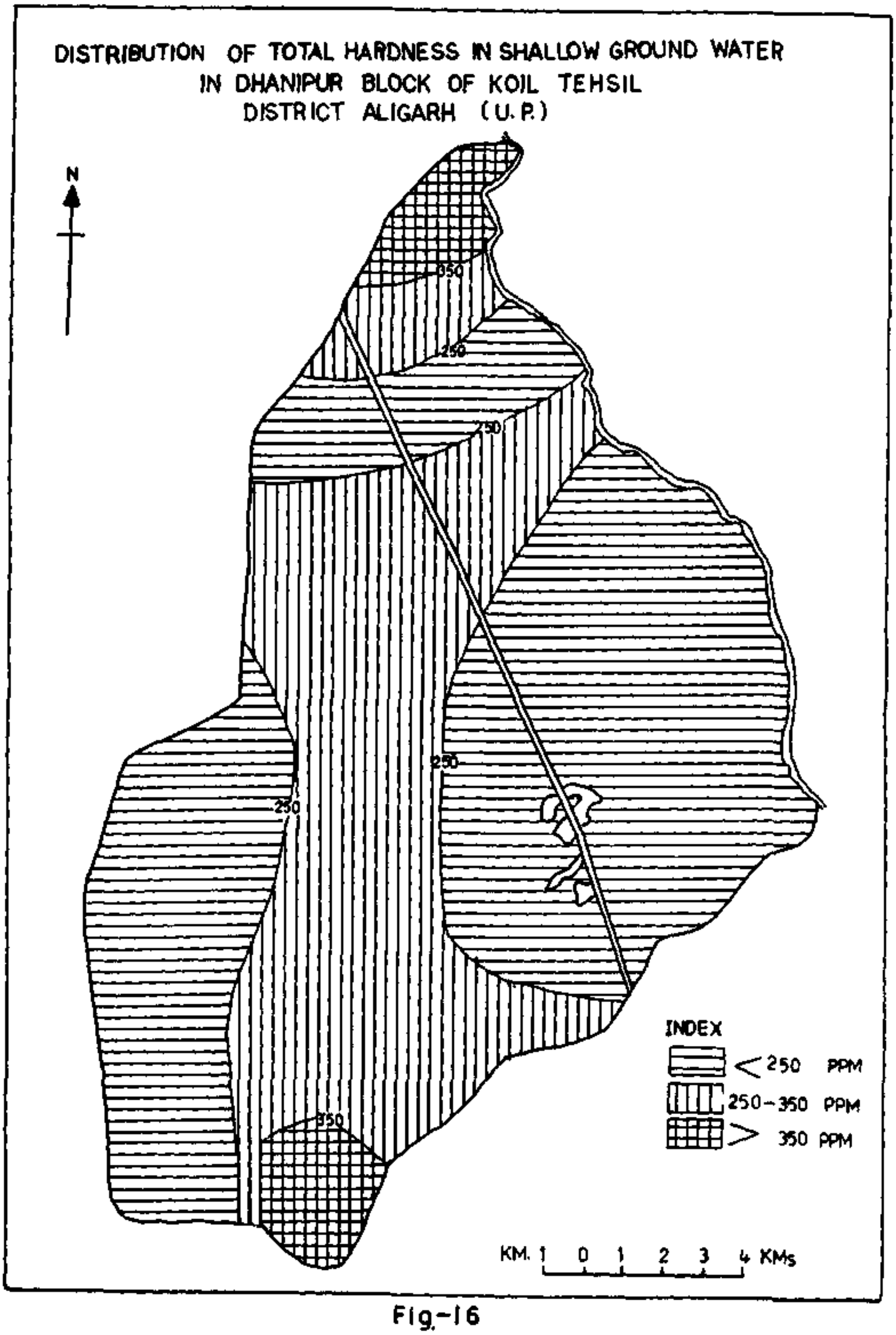
sample of Rohana Singhpur. It may be added that bicarbonate content in ground water is dependent upon the partial pressure of carbon-dioxide in the soil. Bicarbonate shows fluctuation depending upon $CO_2$ pressure in the soil, quite independent of the aquifer characteristics.

5. **Chloride:**

Indian Council of Medical Research (1974) while recomending 200 ppm as desirable limits of chloride in potable waters has also laid down 1000 ppm as maximum permissible limit where no other alternative source is available. Chloride map has been prepared (Fig-15). As it is evident from the illustration that in major part of the area the chloride concentration in shallow ground water is below 200 ppm. The maximum concentration of chloride is recorded in ground water sample of Ukhlana.

6. **Sulphate:**

The sulphate concentration has been found to vary from 44 ppm to 417 ppm. The highest value of 417 ppm has found in an open well at Ukhlana. In major part of the area, the sulphate concentration was found within the permissible limit of 250 ppm. High concentration of sulphate may be because of sodium sulphate and low concentration probably may be because of less oxidation of sulphide to



DISTRIBUTION OF TOTAL HARDNESS IN SHALLOW GROUND WATER
IN DHANIPUR BLOCK OF KOIL TEHSIL
DISTRICT ALIGARH (U.P.)
N
350
250
250
250
250
350
INDEX
< 250 PPM
250–350 PPM
> 350 PPM
KM. 1 0 1 2 3 4 KMs


Fig.-16

sulphate.

**7. Total Hardness:**

This has been measured as $CaCo_3$ and ranges from 118 ppm to 460 ppm. Most of the water in the study area (Fig-16) is found within the permissible limit of 300 ppm. At places the concentration was found higher then the permissible limit. The highest value of 460 ppm was recorded in Ukhlana well.

**8. Sodium:**

The concentration of sodium ranges from 10 ppm to 298 ppm. The highest concentration of sodium was recorded in ground water sample of Ukhlana. However, the concentration of sodium was found well within the permissible limits. Sodium concentration in drinking water around 200 ppm may be harmful to persons suffering from Cardiac, renal and diseases pertaining to circulatory system.

**9. Potassium:**

The concentration of potassium ion in ground water varies from 3 to 491. The highest concentration of potassium has been found in Ukhlana Well water sample. The concentration of potassium is generally low in ground water, potassium salts are of therepeutic value in the treatment of familiar periodic Paralysis while no desirable or excessive limit for potassium seems to have been set, though 1000-2000 ppm seems to be the extreme limit for potassium ion in drinking water.

## 10. Calcium:

Calcium is an essential element and human body requires 0.7 to 2.00 gram per day. However, larger doses may be required to pregnent or lactating womens or growing children. The absence of calcium in very soft waters has been considered responsible for rickets, decayed teeth etc. while hard waters having high calcium concentration may add to urinary disorder etc. The limits of calcium in drinking waters are not based on health consideration as even waters having 100 ppm of calcium is harmless. An average daily adult requirement of calcium is 10 mg/kg of body weight and for growing children 40.6 mg/kg of body weight.

The concentration of calcium in the ground water of the area varies from 100 ppm to 79 ppm. The highest value is recorded in well water of Kondra.

## 11. Manesium:

It is one of the constituents responsible for hardness of water, while the low concentration are not harmful, higher concentration are laxative. The concentration of magnesium has been found to be vary from 16 ppm to 64 ppm. The highest concentration was found in the well water of Bara Nadi. Except one mostly the values are well within the permissible limit of 50 ppm.

TOTAL DISSOLVED SOID:

The total dissolved solids are directly related with electrical conductivity or salinity. Indian Council of Medical Research while recommending 500 ppm TDS in potable water has also laid maximum permissible limits of 1500 ppm TDS, where no alternate source is available. TDS ranges between 208 ppm to 1574 ppm. The highest value of 1574 ppm was recorded Ukhlana well water.

TRACE ELEMENTS:

Certain elements, the so called trace elements in very low concentration play a very important role in the diets of human and animals and in the healthy growth of the plants. However, these every elements at higher levels may prove injurious or even toxic to animal plant life. Although human being and animals may get a part of total intake of these trace elements through diet or food, a part may also be supplied through the medium of drinking water and beverages. Deficiencies of 20-24 elements in man and animals (Friedin, 1972) and 13 to 17 elements in plants have been recognised (Epstein, 1965). It must be stated that it is not the overall concentration of an element that is important, but the species of metal present in water that is available to an organism or plant that must be taken into consideration. The present describes the total concentration of parameter or trace constituents present in ground water in the study area.

**1. Iron:**

It is an essential nutrient for humans, animals and plants (Faribanks et al., 1971). Its concentration in the shallow ground water ranges between 0.095 ppm to 0.438 ppm. The highest value was recorded in open well water at Nagla Sirawali. The concentration of iron in the study area is within the permissible limit.

**2. Mangnese:**

The mangnese concentration varies between 0.066 ppm to 0.309 ppm. The highest value was recorded in well water at Bhudansi.

**3. Copper:**

Copper concentration ranges between 0.016 ppm to

0.074 ppm which is below the permissible limit for the use of drinking water. The highest value was recorded in open well water at Rohana Singhpur.

**4. Zinc :**

The concentration of zinc ranges between 0.067 ppm to 0.235 ppm. The maximum value was recorded in open well water at Rohana Singhpur while the minimum value at Edalpur.

**5. Nickel:**

The concentration of nickel varies between 0.017 ppm to 0.037 ppm. The analytical result shows that the nickel content in the water is low. The highest value was recorded at Rohana Singhpur well water while the lowest value at Adun well water.

**6. Cobalt:**

The cobalt concentration has been found to vary from 0.061 ppm to 0.088 ppm. The highest concentration of cobalt has been found in Adun well water sample.

**7. Lead:**

The concentration of lead ranges between 0.013 ppm to 0.075 ppm. The concentration of lead found well within the permissible limit recommended by World Health Organisation

TABLE - 5

Drinking water standards

| S.No. | Constituents | Indian Standards Institution (1983) | | World Health Organisation (1971) | | Concentration observed in Dhanipur Block in mg/l | |
|---|---|---|---|---|---|---|---|
| | | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| 1. | PH Range | 6.5 to 8.5 | 6.5 to 9.2 | 7.0 to 8.5 | 6.5 to 9.2 | 6.93 | 8.08 |
| 2. | Total Hardness (mg/l as CaCo3) | 300 | 600 | 100 | 500 | 118 | 460 |
| 3. | Calcium(mg/l as $CaCO_3$) | 75 | 200 | 75 | 200 | 10 | 79 |
| 4. | Magnesium(mg/l as Mg) | 30 | 100 | - | 150 | 16 | 64 |
| 5. | Copper(mg/l as Cu) | 0.05 | 1.5 | 0.05 | 1.5 | 0.016 | 0.074 |
| 6. | Iron(mg/l total as Fe) | 0.3 | 1.0 | 0.1 | 1.0 | 0.095 | 0.438 |
| 7. | Maganese(mg/l as Mn) | 0.1 | 0.5 | 0.05 | 0.5 | 0.066 | 0.309 |
| 8. | Chloride(mg/l as Cl) | 250 | 1000 | 200 | 600 | 57 | 526 |
| 9. | Sulphate(mg/l as So4) | 150 | - | 200 | 400 | 44 | 417 |
| 10. | Cadium(mg/l as $SO_4$) | 0.01 | No relaxation | - | 0.01 | 0.033 | 0.070 |
| 11. | Lead(mg/l as pb) | 0.1 | " | - | 0.1 | 0.013 | 0.075 |
| 12. | Hexavalent chromium (mg/l as Cr+6) | 0.05 | " | - | - | 0.037 | 0.079 |

(W.H.O., 1984). The maximum concentration was recorded in Khan Alampur Well Water.

8. **Cadmium:**

Cadmium has a cumulative and highly toxic effect on man. The concentration vary from 0.033 ppm to 0.070 ppm. The highest concentration was recorded in the ground water sample of Rohana Singhpur.

9. **Chromium:**

An alarming concentration of chromium hexavalent was observed at many places. It generally ranges between 0.037 to 0.079 ppm. The highest concentration was observed in the ground water sample of village Adun.

10. **Lithium:**

The concentration of lithium ranges from 0.032 ppm to 0.160 ppm. It is not harmful for domestic use. The highest value was recorded in the well water at Khan Alampur.

11. **Rubidium:**

Rubidium is a rare element and occurs in nature dispersed with potassium. The concentration of rubidium ranges between 0.127 ppm to 0.270 ppm. The highest value was recorded in the well water at Rohama Singhpur.

12. **Barium:**

The concentration of barium ranges between 0.025 ppm to 0.106 ppm. The highest concentration was observed in the well water at Bhudansi.

13. **Strontium:**

It is an essential element for the calcification of bones and teeth. The concentration of strontium ranges between 0.089 ppm to 0.881 ppm. The highest value was found in the open well water of Edalpur.

WATER QUALITY CRITERIA:

Water the most vital resource for all kinds of life on this planet is also the resource, adversely affected both qualitatively and quantitatively by all kinds of human activities on land, in air or in water.

The increasing industrilization urbanisation and other developmental activities and their impact has created a veritable water crisis. Today most of the river of the world receive millions of litres of sewage, domestic waste, agricultural and industrial effects containing substances varying in characteristics from simple neutrient to highly toxic substances. The fate of ground water is also same in most of the areas. The industry continues to be one of the most significant causes of pollution of aquatic ecosystem due to diverse kind of waters produced by them.

The term quality as applied to water embraces the combined physical, chemical and biological characteristics and is a dominent factor in determining the adquancy of any supply to satisfy the requirements of various water uses.

The interpretation of a chemical analysis is a highly subjective matter and it is not possible to have a single criteria that can have universal application. Therefore, a certain accepted standard has been adopted while doing the interpretation of chemical analysis results of water in relation to its use for domestic, irrigation and industrial uses. with this object in view following criteria has been adopted for interpretation of the result.

I. Water quality for Domestic and municipal uses:

Various Organisation all over the world viz. U.S. PHA (1962), WHO (1960, 1963 and 1971) USEPA (1973), ICMR (1975) have laid down certain guidline for evaluation of water quality for domestic supplies and accordingly the concentration of various ions has already been discussed under the heads - calcium, chloride, total dissolved solids and Fluride, Nitrate were not determined due to some difficulties.

<u>High level concentration of heavy toxic elements in the ground water of Dhanipur Block and their possible relation with various health hazards</u>. The past three decades have seen remarkable advance in the appreciation of significant role played by the trace elements in the diets of humans, animals and plants growth. However, these elements at higher concentration may prove injurious or even toxic to animal and plant life. Although human being and animals may get a part of total intake of these trace elements through diet or food, a part may also be supplied through the medium of drinking water and beverages. However, most authorities have laid down upper limits on the permissible concentration, of these constituents in potable waters. The analytical result shows that certain trace elements in the ground water of Dhanipur Block are higher than the permissible limit which are as follows.(Table-6)

TABLE - 6

Toxic Trace Elements

| Elements | W.H.O. Standards in mg/l | I.C.M.R. Standards in mg/l | Concentration in Dhanipur Block in mg/l | |
|---|---|---|---|---|
| | | | Minimum | Maximum |
| Cd | 0.01 | 0.01 | 0.033 | 0.070 |
| Cr | 0.05 | 0.05 | 0.037 | 0.079 |
| Pb | 0. 1 | 0.1 | 0.013 | 0.075 |
| Fe | 0.1 | 0.3 | 0.095 | 0.438 |
| Cu | 0.05 | 0.05 | 0.016 | 0.074 |
| Mn | 0.05 | 0.1 | 0.066 | 0.309 |

Among all toxic metals cadmium has drawn very much attention. In high concentration it is deadly poison, but small amounts of cadmium taken over a long period of time accumulates in the biological system and causes serious illness (Verma, 1987). After accumulation it is retained mainly in liver and kidney, thus causing the pathological changes of the hepatocytes of the liver and kidney, tubules and glomeruli changes (Itokawa et al., 1974, Colucci et al., 1975). The two major effects of Chronic Cadmium toxcity in persons that have been occupationaly exposed to cadmium are obstructive lung diseases and renal dysfunction. The lung disorder are primarily suggestive of pulmonary emphysema. The most common abnormality from Chronic Cadmium exposure involves renal toxcity characterized by proteinurea. Other disturbances of renal tubular function include glycosuria, Amino acid uria, decreases the Urine concentrating ability, and abnormalities in renal processing of uric acid, calcium and phosphorus.

Hexavalent chromium is highly toxic while the trivalent chromium is essential for efficient lipid, glucose and protein metabolism (U.S. Environmental protection Agency Part II, 1983). Signs of toxcity of its compounds include hemorrhage of the gastrointestinal tract, ulceration of nasal septum, cancer of respiratory tract and dermatitis (National

Academy of Science, 1974). It is evident that people taking ground water with high concentration of chromium are likely to suffer from the above mentioned diseases (Singh and Bhayana, 1986).

Lead is also a toxic metal and tends to accumulate in the tissues of man and animal. Lead poisoning symptoms usually develop slowly. The pregnant woman are most sensitive to environmental lead exposure (W.H.O., 1973; Synder et al., 1971). Lead has been demonstrated to be extremely deleterious as related to haem-biosynthesis. The elevated blood lead disrupt the blood enzyme delta-amino levulinic acid dehydrate (ALAD) activity in human, and can induce reduction in haemoglobin (Chisholm, 1971; Goyer and Rhyne, 1973). The lead is also responsible to cause mental retardation in children, increased abortion rates in female and infertility in males. Recent literature shows that it is also a causative factor of hypertension (Verma, 1987). The concentration of lead in the ground water of Dhanipur Block is within the permissible limit.

Iron is essential element in human nutrition but becomes toxic when it crosses the permissible limit. Affected persons are frequently develop diabetes mellitus and heart failure. These syptums are caused by a toxic accumulation of Iron in the body tissues.

Mangnese activates a host of critical intercellular enzymes. Higher concentration may cause neurological syndrome (Anon, 1977). Its play a role in oxidative phosphorylation, fatty acid metabolism etc.

Copper is essential in human metabolism (W.H.O., 1973) and is critical to such diverse activities as hemi-synthesis, connective tissues metabolism, bone development and nerve function. Elevated concentration of copper in serum are observed in a large number of acute and chronic diseases. The greatest danger of toxcity arises when children consume acidic beverages that have been in contact with copper containers or values (Food and Drug Administration, 1975).

WATER QUALITY FOR IRRIGATION PURPOSES:

Water quality criteria for Irrigation is a complex subject and as such it has not been possible to have an agreed criteria on a universal basis, because growth of a particular crop depends on many factors and not merely on chemistry of irrigation water. Factors to be considered in evaluating the usefulness of ground water for irrigation are: The total concentration of dissolved solids, the concentration of individual constituents, the relative proportion of some of the constituents, the nature and composition of the soil and sub-soil, the topography of the land, the position of the water table, the amounts of the ground water used and the methods of applying it, the climate of the area and the method of crop management (Walton, 1970).

The data obtained from detail chemical analyses of water samples were processed and interpreted on the established guidelines as discussed below.

**I. Salinity and Sodium Hazards:**

Irrigation water is one of the major contributors of soluble salts to the soil in addition to those already present. It is the water that is removed by evaporation or transpiration, and these are the two process which ultimately control the degree of osmotic stress to which plant will be exposed. In the shallow water table area where the ground water is saline, the evapotranspiration process also creates a suction force that may produce an appreciable upward flow of water and salts to the root zone by which many types of soil become salanized and the water soil salinity becomes so high as to retard the germination of seed or growth of plants.

In place of rigid limits of salinity for irrigation water, quality is expressed by classes of relative suitability

(Wilcox, 1955). Wilcox prepared a classification based on the Electrical conductivity, Sodium percentage, Boron concentration and Residual Alkalinity which is given in Table - 7.

## T A B L E - 7

**Guide to the Quality of Irrigation Water**

| Specific conductance mmho/cm | Sodium percentage | Boron ppm | Residual Na2 Co3 mg/l | Quality of Irrigation water |
|---|---|---|---|---|
| < 0.75 | > 65 | 0.3-1 | << 1.25 | Excellent to good |
| 0.75-2.00 | 50-65 | 0.7-2 | < 1.25 | Good to permissible |
| 2.00-3.00 | 92 | 1-3 | 1.25-2.5 | Doubtful to unsuitable |
| > 3.0 | > 92 | 1.2-3.8 | > 2.5 | Unsuitable |

Total dissolved solids are generally interpreted as electrical conductivity and irrigation water classification based on electrical conductivity is given below. The U.S.

Salinity Laboratory Staff (1954) has proposed the use of the Sodium Absorption Ration (S.A.R.) for Studying the suitability of ground water for irrigation purposes. It is defined as

$$S.A.R. = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

(Concentration are in epm)

T A B L E - 8

Quality Classification of Irrigation Water (After USSL, 1954)

| Classification | Electrical unductivity in micromohos/cm | Salinity Hazards | Alkali Hazards (S.A.R.) |
|---|---|---|---|
| i) Excellent | $<$ 250 | LOW | upto - 10 |
| ii) Good | 250-750 | Moderate | 10-18 |
| iii) Moderate (permissible with caution) | 750-2250 | Medium high | 18-26 |
| iv) Unsatisfactory | 2250-4000 | High | $>$ 26 |

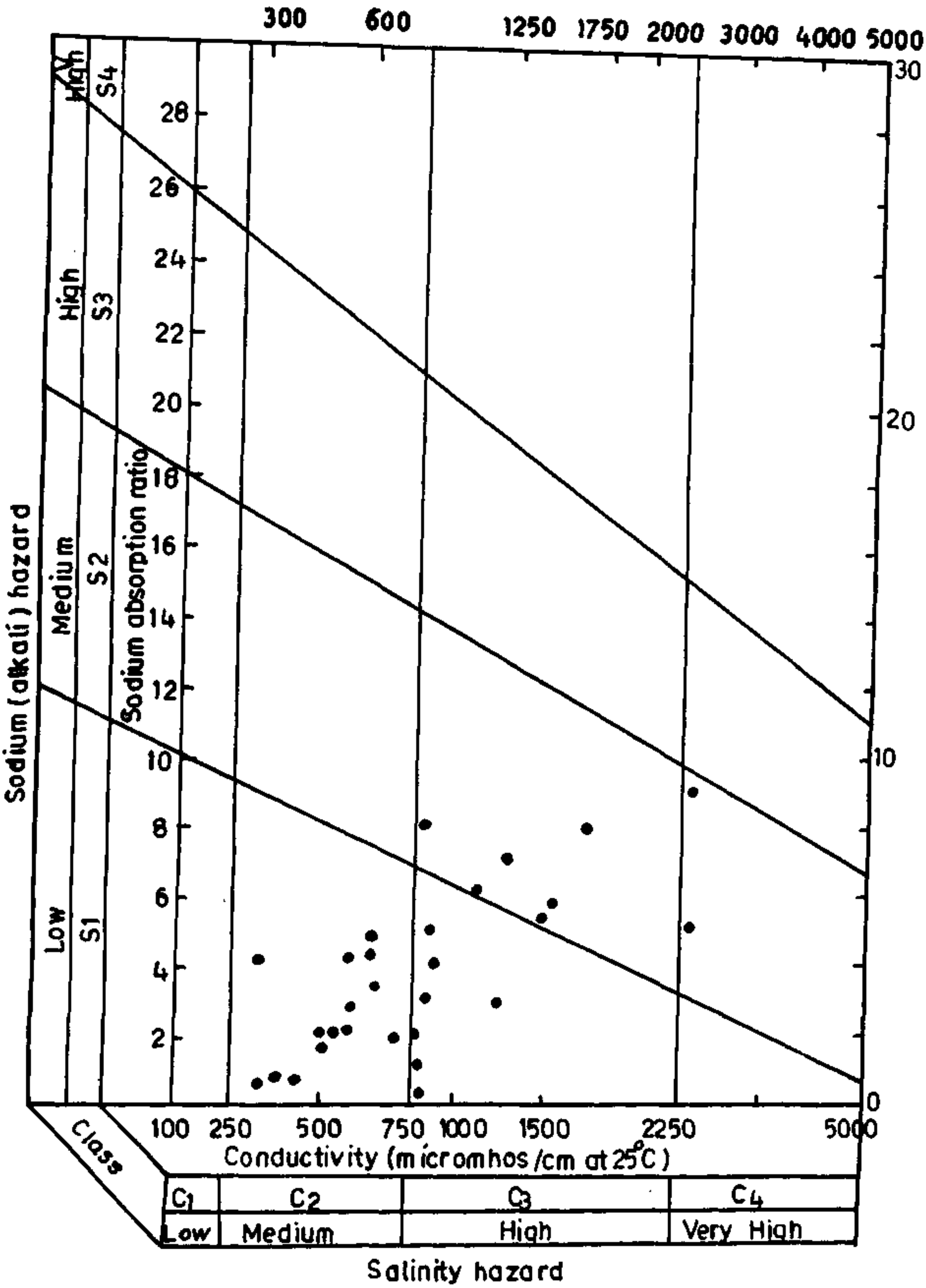



Fig.—17. SHOWING PLOTS OF SAR VALUES AGAINST E.C VALUES

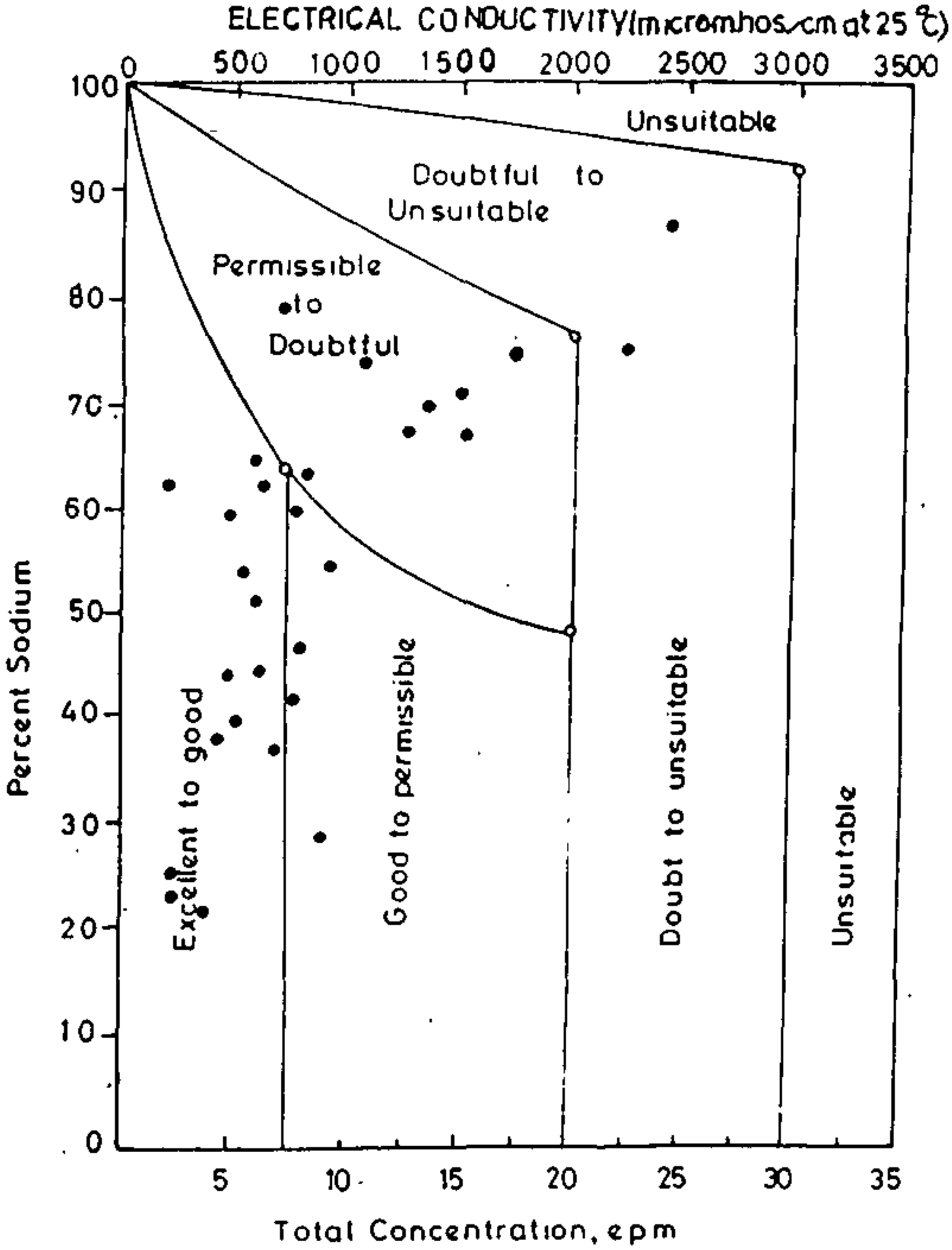



Fig.-18. SHOWING PLOTS OF SODIUM PER CENT AGAINST E.C. VALUES.

The results of chemical analysis of the ground water shows that the quality of water is suitable for irrigation. Because it belongs to class-2 good and class-3 moderate with moderate to medium high salnity hazards. Two samples of ground water belong to class-4 unsatisfactory, and may be due to the addition of fertilizer.

Presence of sodium ion in water is responsible for effecting the physical conditions of the soil because it replaces the calcium ion from the soil and make it sodium soil. Thus the extent of sodium ion in relation to calcium and magnesium ions in dissolved solids is more indicative of soluble salts alone. As such water classification based on sodium absorption ratio is considered to be a better indicator of the quality of water for irrigation purposes and significance of classification has been presented diagramatically in (Fig-17).

From both diagram it is seen that the majority of ground water samples belong C2 S1, C3 SI C3 S2 class and Excellent to good, good to permissible, permissible to doubtful, Doubtful to unsuitable (fig-18) which may be used for irrigation purposes. Soil water management and proper drainage facilities will be required in order to avoid hazards and long continuous use.

TABLE - 9

Trace elements tolerance limit of irrigation water as proposed by FWPCF (1968) and Ayers and Branson (1975). (Concentration expressed in ppm)

| Elements | Water use(FWPCF,1968) | | Water use(Ayers and Barson, 1975) | |
|---|---|---|---|---|
| | Continuous - | Short term in fine textured soils | Continuous - | Short term in fine textured soils |
| Copper | 0.20 | 5.0 | 0.20 | 5.0 |
| Iron | - | - | 5.0 | 15.0 |
| Lithium | 5.0 | 5.0 | 2.5 | 2.5 |
| Mangnese | 2.0 | 5.0 | 0.2 | 10.0 |
| Strontium | - | - | - | - |
| Nickel | 0.5 | 2.0 | 0.2 | 2.0 |
| Zinc | 5.0 | 10.0 | 2.0 | 10.0 |
| Cadmium | 0.005 | 0.05 | 0.01 | 0.05 |
| Cobalt | 0.20 | 10.0 | 0.05 | 5.0 |
| Lead | 5.0 | 10.0 | 5.0 | 10.0 |
| Chromium | 5.0 | 0.05 | 0.1 | 1.0 |

TRACE ELEMENTS CONCENTRATION:

In addition to major ions needs of some trace elements are now being recognised as benificial to the crops for proper growth of the plants. These trace elements are Cu, Zn, Fe, Ni, Mn, Co, etc.are very necessary for the proper growth of plants. Federal Water Pollution Control Federation U.S.A. (1968) and Ayers and Branson, (1975) put forward the tolerance limit for irrigation water (Table - 9).

Perusal of analytical results reveal that the concentration of above micro nutrients in the ground water of Dhanipur Block are within the recommended limit of Federal Water Pollution Control Federation (1968) and Ayers and Branson, (1975). There will be no any toxic effect to plants if waters are used continuously for irrigation purposes.

WATER QUALITY FOR INDUSTRIAL PURPOSES:

For different industry water quality differ widely. Pure waters are required for the manufacture of pharmaceuticals, paper and beaverages.

An extensive survey was carried out in U.S.A., in respect of copper industry, the results of which are useful in many other base metal industries showed that water of very high purity is required for refining where as for certain phases of mining and floatation processes, the quality may not be critical (Karanth 1987).

The accepted classification of water with regards to hardness is as follows.

TABLE - 10

Classification of water on the basis of hardness

| Class | Hardness |
|---|---|
| 1. Soft | 0-60 |
| 2. Moderately hard | 61-120 |
| 3. Hard | 121-180 |
| 4. Very hard | More than 180 |

The study shows that the ground water in Dhanipur Block are suitable for domestic, irrigation and industrial uses.

......

# SUMMARY AND CONCLUSION

# SUMMARY AND CONCLUSION

The study area Dhanipur Block spread over an area of 293.94 sq. km. forms a part of Kali - Sengar Doab and lies in Central Ganga basin. As regards the origin of Ganga basin, it was interpreted to be formed as a foredeep; or a great rift valley which was later filled up with alluvium of the thickness 4.5 km to 20 km. A third view regards it a sagging in the crust, while the forth more accepted view presents it as a buckling down in the crust. According to another recent view it is thought to be a resultant of phenomenal sagging of the Nothern platform of the Bundelkhand shield following the main Himalayan episode. Another supported view considers the Indo-Gangetic plain, a peripheral foreland basin formed a result of continent-continent Collision between Indian and Asian plates.

Consequent to the oil and water well drilling in the Ganga basin, the sub-surface topography beneath the Quarternary alluvium is found to consist of alternate spurs and depressions. The northern fringe of the peninsula is intact close to the right bank of the Ganga, but Ganga itself flow presently along the fault plane, the northern side of which is down thrown side. Accordingly, the thickness of the alluvium increases due north and attains its maximum at foothill zones in Sarda basin. The area under study lies on the western flank of Aligarh-Kasganj-Tanakpur Spur and south of Ramganga Depression. Quarternary sediments, comprising clay and sands of Various grades in multiple alternations, were deposited on the eroded and upturned surface of Upper Vindhyan rocks leading to the present configuration.

Hydrogeologically speaking, there occurs two to three tier aquifer system in the Block, down to 160 metres depth below ground level. By and large these aquifers appear to merge with each other and behave as single bodied aquifer system. The upper most aquifer is extensive and highly potential depth range 12 to 70 m with an average of 50 m.b.g.l. The second aquifer is of limited areal extent and thickness (10 m) while third aquifer attains a sizable thickness of 40 m.

The granular zones comprising medium to fine, grey micaceous sands, occasionally intermixed with coarse sands and gravel forms about 60 per cent of the total formation encountered down to 160 m.b.g.l., in the central part of the area. The ground water of the area occurs under water table condition in shallow aquifers and semi-confined to confined conditions in deeper aquifers.

The pre-monsoon depth to water level varies between 3.20 to 14 metres b.g.l. and post-monsoon depth to water level between less than 2 to 14 metres b.g.l. In general the water level fluctuation is recorded between 0.5 to 2.5 metres. The Upper Ganga Canal passes through the central part of the area. The seepage from the canal bed into the shallow aquifer has led to acute water logging - soil salinity conditions adjacent to the canal, resulting thereby to the development of ground water mound around the canal. The ground water from the eastern flank of the mound flows due east to join river Kali. The river Kali is effluent in nature.Ground water from the western flank of the mound flows towards the Aligarh city to fulfill the high demand of thick population and industrial needs.

A perusal of the water table contour map shows a ground water trough on the south western end of the Block. This has probably developed due to the excessive withdrawal of ground water, through cluster of tubewells, much higher than the quantum of average annual recharge. Situation has generated a declining trend of water level in contrast to the water logging condition along the canal. Some provision for recharge of the depleting aquifers should be made. In this view a canal be passed through to arrest the declining trend of the water level in the area.

Water balance studies evince that the net recharge of the Block is 43.65 MCM and the net draft is 26.85 MCM, leaving a balance of 16.80 MCM as utilizable resource potential. As per NABARD'S norm the status of the ground water development is 61.51 percent and accordingly. Block falls under 'White' category. In view of 61.51% ground water development, there is a wide scope for the large scale ground water development through shallow and deep tubewells.

The ground water of the area is good, potable and suitable for domestic as well as irrigation purposes. Shallow aquifers are highly poluted with the heavy toxic metal like Cd, Cr, Pb, Fe, Cu etc., which may entail various health hazards to its users. With the advent of planning at district level, the block level ground water resource estimation has attained a great importance. The assured irrigation through ground water has revolutionised the food grain production in the block, which very well testifies its role in the development of agriculture. High yielding varieties of the crops like wheat, paddy, sugar cane and also vegetables which is grown whole the year need assured irrigation in time. The study shows that ground water resource is available for irrigation, so the government should manage more shallow tubewells for irrigation to increase the foodgrain production in the block.

.....

# REFERENCES

# R E F E R E N C E S

Agrawala R.R. & Malhotra C.L. 1953. Soil survey and Soil work in U.P. Vo. 1.

APHA; 1975. Standard methods for the examination of water and wastewater, 14th Edn. American Public Health Association, Washington, D.C.

Anon, 1977. Outbreak of Paralysis in Villages of Unnao district, U.P. A preliminary Epidemiological Study, ITRC Momoir No.1.

Ayers, R.S. and Branson, R.L. 1975: Guide lines for interpretation of water quality for Agriculture, University of California, Extension Meimeograph, P.13.

Berg, J.W. and Burbank, F; 1972: Geochemical Environment in Relation of Health and Disease, Ann. N.Y. Acad. Sci. 199, 249-264.

Burrard, S.G. 1915: Origin of the Indo-Gangetic trough, Commonly Called Himalyan fore deep; Proc, Roy, Soc. London, 91A, P. 220-238.

Chandra, S. 1984: Groundwater Resource Assessement, proceeding International workshop on "Rural Hydrology and Hydraulics in Fissured Basement zones, March 15-24, 1985, Silver Jubilee year, Department of Earth Science, University of Roorkee, Roorkee.

Chisholm, J.J., 1971: Leac poisoning, Scient, Am 224, 15-23.

Colucci, A.V., Winge, D., and Krasco, J., 1975, 'Codmium Accumulation in the Rat Liver', Arch. Environ. Hlth 30, 153-157.

Craun, G.F. and McCabe, L.G. 1975: Problems Associated with Metals in Drinking water, J.Am. Wat. Wks. Asso., 67-593-599.

Dickinson, W.R., 1974, Plate tectonics and sedimentation. IN: W.R. Dickinson (Ed.) Techtonics and Sedimentation. Spec. Publ. Soc. Econ. Geol. Paleont., V.22, pp 1-27.

Drinking water and Health, 1980: Vol. 3, National Research Council Washington, DC.

Dutt, D.K. 1969: Hydrogeology of the Aligarh district Uttar Pradesh, Indian Minerals, 23(2), p. 1-14.

Encyclopaedia - Britanica, 19783-74: Encyclopaedia Britanica, Vol. II 1973-74, pp. 1119.

Fairbanks, V.F., Fahey, J.L. and Beutler, E, 1971: Clinical Disorders of Iron Metabolism, 2nd ed. Grune and Stratton, New York, 486 pp.

Fedral water Pollution control Federation, 1968: Report of Committee on water quality Criteria, Washington, D.C., p. 234.

Fleisher, M., Sarofim, A.F., Fassett, D.W. Hammond, P., Shacklette, H.T. Nisket, I.C.T., and Epstein, S.1965: Environmental Impact of Cadmium: A Review by the panel on the Hazardous Trace substances, Environ. Health perspect 7, p. 253-323.

Food and Drug Administration, 1975: Toxicity of Essential Minerals information pertinent of Establishing Appropriate levels of single Mineral Dietary supplements, Division of Nutrition, Bureau of Food, Food and Drug Administration 231 p.

Goyer, R.A. and Rhyne, 1974: Pathological Effects of Lead, Rev. Exp. Pathol. 12, p. 17.

Hem, J.D. 1959: Study and Interpretation of the chemical characteristics of Natural water. U.S. Geol. Survey water supply paper, p. 473.

I.C. M.R., 1975: Manual of standard of Quality for Drinking water supplies, India Council of Medical Research New Delhi 2nd Edition.

Itokowa, Y., Aba., T., Tabei., R., and Tanaka, S.: 1974, 'Renal and Skeletal Lesions in Experimental Cadmium Poisoning', Arch Environ. Hlth. 28, p. 1842.

Kranth, K.R., 1987: Ground water Assessment, Development and management. First edition Tata Mc Graw Hill, p. 720.

Krishnan, M.S. 1982: Geology of India and Burma, Sixth Edition p. 536.

National Academy of Science: 1974, Chromium Report of the Subcommittee on Chromium, Committee on Biologic Effects of Atmospheric Pollutants, National Academy Sciences, Washington, D.C. 250 pp.

National Academy of Science, 1977: Drinking water and Health 279-283 Washington, D.C.

Nevill, H.R., 1909: Gazetteer of Aligarh District, Vol. VI, p. 218-222.

Oldham, R.D., 1917: The structure of the Himalyas and the Gangetic plains. Me., Geol. Survey of India, 42(2), p.153.

Olwin, J.H., 1977: Metals of the life of Man, J. Am. Wat. Works, Assoc., 67, P. 403-409.

Pattak, B.D., 1978: Hydrogeology and Ground Water Potential of U.P.

Pattak, B.D., 1985: Ground water in India and Scope for Future Development, Current Trinds in Geology VII-VIII, p.573-511

Pascoe, E.H., 1964: Amanual of Geology of India and Burma Govt. of India press, Calcutta, p. 21.

Raiverma, V., Kunte, S.V. Mukherjee, 193: Basin Geometry, cenozoic sedimentation and Hydrocarbon prospect in North western Himalyan and Indo Gangetic Plains K.D.M.PE., O.N.G.C., Petroleium Aria Journal, India p. 67-9.

Rao, G.K. 1987: Ground water recharge Estimates by Radio Isotope method - critical analysis. Journal Geological Society of India Vol. 29, Jan., 1987, pp. 180-188.

Rao, K.V. and Raju, T.S. 1965: Quantitative studies on Ground water storage, Recharge, Draft and Safe Yield in the Atrauli Area, Aligarh district, U.P. Indian Geohydrology 1(1)p.46-6

Rao, M.B.R. 1973: The Subsurface geology of the Indo-Gangetic Plains, Jr. Geol., Soc. India, 14(3), p. 213-242.

Sastri, V.V., Venkatachala, B.S., Bhandari, L.L. Raju A.T.R. and Datta A.K., 1971: Tectonic Frame work and subsurface straitigraphy of the Ganga Basin. J.Geol., Soc., India 12(3), p.223-233.

Schroeder, I.H., Balassa, J.J. and Tipton, I.H., 1961: Abnormal trace Metals in Man Nickel J. Chronic Diseases 15, p. 51-65

Schienber, I.H. and Sternleib, 1965: Wilson's Disease Annu,Rev, Med, 16, p. 119-134.

Schroeder, H.A. and Kraemer, L.A., 1974: Cardiovascular Mortality, Minicipal Water and corrosion Archs, Environ. Hlth 28, p. 303-311.

Singh, K.P. and Bhayana Naresh, 1985: Geochemistry of Ground water of Ludhiana area, Punjab, with special reference to its use for irrigation and domestic perpuses current Trends in Geology Vol. 8-IVth Indian Geological congress, pp. 579-594.

Suess, E., 1904-1924: The face of the earth 5 clarenden press Oxford.

Synder, R.B., Whebbles, D.J., Pearson, J.E. and Ewing, B.B., 1971: A study of environmental Pollution by Lead, Institute of Environmental study, Estate of Illinoise II EQ Doccument No. 717.

Todd, D.K. 1980: Ground water Hydrology Second Edition, Jhan willey and Sons p. 535.

Trivedy, R.K. and Goel., P.K. 1984: Chemical and Biological Methods for Water Pollution Studies, Environ. Publications, Karad, India, pp. 215.

U.S. Environmental Protection Agency: 1983, National Revised Primary Drinking Water Regulations, Advance Notic of Proposed Rule making. F.R. Vol. 48, No. 194, 45512, Washington D. C., October 5.

U.S. Salinity Lab Staff, 1954: Diagnosis and improvement of saline and Alkali soils, U.S. Dpett. of Agriculture Circ. 969.

USEPA, 1983: National Revised primary Drinking water Regulations, Pederal Registrar October, 5 48(194), Part II.

USPHS, 1962: Public Health service Drinking water standards Publications 956, US Govt. Printing Office Washington D.C.

Valdiya, K.S. 1982: Geology of Vindhyachal, Hindustan Publishing Corporation, India.

Verma, M.M. 1987; Health Hazards from water, The Hindustan Times, New Delhi, Saturday April 18, 1987. pp.17.

Vohra, B.B; 1986: Toards a National Water Policy. Bhu-Jal News, V.2 No.1, p.3-4

Walton, W.C. 1970: Ground water Resource Evaluation Mc Graw Hill series in water Resources and Environmental Engineering p. 664.

Webb, M., 1975: Cadmium Br, Med. Bull 31, p. 246-250.

Wilcox, L.V., 1955: Classification and use of Irrigation waters, U.S. Deptt. of Agri. Circ. 969.

World Health Organisation 1973: Technical Report Series, Trace element in human nutrition, report of W.H.O. expert Committee No. 532.

World Health Organisation 1977: Environmental Health criteria for Cadmium, Ambio 6. 287-290.

World Health Organisation, 1984: Guideline for Drinking Water Quality. W.H.O., Geneva.

## REFERENCES*


Ahmad, M.S., Ali, A. and Umar, R. 1988. Groundwater management and water balance studies of Aligarh Muslim University Campus, district-Aligarh, U.P., Jour. of Engg. Geol., Vol. XVII No. 1 & 2, pp. 7-13.

Ali, A., 1987. Hydrogeology and groundwater potential in and around A.M.U. campus, district-Aligarh, U.P., Unpublished M.Phil. dissertation, Aligarh Muslim University, Aligarh U.P.

Fahmi and Nazir, K.K., 1986. Aquifer system and groundwater potential of A.M.U., campus, Unpublished, P.G. diploma dissertation, Aligarh Muslim University Aligarh.


*There are the referenses which has no been taken by typographical mistake in original reference index.

.......

# APPENDICES

# APPENDIX-1(A)

## ANNUAL RAINFALL IN mm AT ALIGARH RAIN GAUGE STATION

| Year | Rainfall | Year | Rainfall |
|---|---|---|---|
| 1951 | 503.0 | 1973 | 371.6 |
| 1952 | 684.0 | 1974 | 412.3 |
| 1953 | 479.0 | 1975 | 697.9 |
| 1954 | 774.5 | 1976 | 502.9 |
| 1955 | 972.0 | 1977 | 857.7 |
| 1956 | 841.3 | 1978 | 1359.8 |
| 1957 | 948.9 | 1979 | 533.5 |
| 1958 | 1178.6 | 1980 | 778.4 |
| 1959 | 712.2 | 1981 | 736.6 |
| 1960 | 895.8 | 1982 | 935.2 |
| 1961 | 1025.2 | 1983 | 1123.2 |
| 1962 | 1153.9 | 1984 | 756.6 |
| 1963 | 1004.9 | 1985 | 933.1 |
| 1964 | 1123.0 | 1986 | 970.2 |
| 1965 | 467.8 | 1987 | 459.4 |
| 1966 | 523.4 | 1988 | 1431.8 |
| 1967 | 697.6 | 1989 | 544.4 |
| 1968 | 409.4 | | |
| 1969 | 544.1 | | |
| 1970 | 417.0 | | |
| 1971 | 560.4 | | |
| 1972 | 69.8 | | |

## APPENDIX - 1 - (B)

**Results of Statistical analysis of annual rainfall, in Dhanipur Block of Koil, Tehsil district Aligarh(UP)**

| Class Interval | Frequency( ) | U | $U^2$ | Uf | $U^2f$ |
|---|---|---|---|---|---|
| 0 - 100 | 1 | -7 | 49 | -7 | 49 |
| 100 - 200 | 0 | -6 | 36 | 0 | 0 |
| 200 - 300 | 0 | -5 | 25 | 0 | 0 |
| 300 - 400 | 1 | -4 | 16 | -4 | 16 |
| 400 - 500 | 6 | -3 | 9 | -18 | 54 |
| 500 - 600 | 6 | -2 | 4 | -12 | 24 |
| 600 - 700 | 3 | -1 | 1 | -3 | 3 |
| 700 - 800 | 5 | 0 | 0 | 0 | 0 |
| 800 - 900 | 3 | +1 | 1 | 3 | 3 |
| 900 - 1000 | 5 | +2 | 4 | 10 | 20 |
| 1000 - 1100 | 2 | +3 | 9 | 6 | 18 |
| 1100 - 1200 | 4 | +4 | 16 | 16 | 64 |
| 1200 - 1300 | 0 | +5 | 25 | 0 | 0 |
| 1300 - 1400 | 1 | +6 | 36 | 6 | 36 |
| 1400 - 1500 | 1 | +7 | 49 | 7 | 49 |
| | f = 38 | | | Uf=4 | $U^2f$ =336 |

Mean Rainfall = $X = Xo+C\left(\frac{Uf}{f}\right)$

$X = 750 + 100\left(\frac{4}{38}\right)$

$= 750 + 10.5$

$= 760.5$

The mean rainfall = 760.5 mm

STANDARD DEVIATION:

$$S.D. = C\sqrt{\frac{U^2f}{f} - \left(\frac{Uf}{f}\right)^2}$$

$$= 100\sqrt{\frac{336}{38} - \left(\frac{4}{38}\right)^2}$$

$$= 100\sqrt{8.842 - 0.011}$$

$$= 100 \times 2.97$$

$$= 297.2$$

Standard Deviation= 297.2

COEFFICIENT OF VARIATION (%)

$$\frac{S.D.}{mean} \times 100$$

$$\frac{297.2}{760.5} \times 100$$

$$= 39.1$$

# APPENDIX - 2

HYDROGEOLOGICAL DATA OF DUG WELLS INVENTORIED IN DHANIPUR BLOCK OF KOIL TEHSIL, DISTRICT - ALIGARH (U.P.)

| S.No. | Well No. | Location | Owner's Name | Depth of Well (in M) | Diameter of Well (in M) | M.P A.G.L. (in M) | R.L of M.P. (a.m.s.l) (in M. | Pre-monsoon Date | D.W.L. B.MP. (in M) | D.W.L. B.G.L. (in M) | W.L. (a.m.s.l.) (in M) | Post - monsoon Date | D.W.L. B.M.P. (in M) | DWL. BGL. (in M) | W.L. (a.msl) (in M) | W.L. F. (in M) | Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) |
| 1. | $W_1$ | Harduaganj | G.S.at Temple | 7.40 | 2.30 | 0.55 | 186.00 | 20.5.89 | 5.20 | 4.65 | 181.35 | 22.10.89 | 3.77 | 3.22 | 182.78 | 1.43 | 25°C |
| 2. | $W_2$ | Morthal | Malkhan Singh | 7.10 | 1.50 | 0.28 | 186.00 | " | 4.70 | 4.42 | 181.58 | " | 2.94 | 2.66 | 183.34 | 1.76 | 25°C |
| 3. | $W_3$ | Barautha | G.S.at Busstand | 5.60 | 1.29 | 0.50 | 187.00 | " | 3.98 | 3.48 | 183.52 | " | 2.52 | 2.02 | 184.98 | 1.46 | 24°C |
| 4. | $W_4$ | Ukhlana | G.S. | 8.90 | 1.60 | 0.65 | 186.00 | " | 6.16 | 5.51 | 180.49 | " | 4.82 | 4.17 | 181.83 | 1.34 | 24°C |
| 5. | $W_5$ | Bhutpura | G.S. | 5.62 | 1.32 | 0.36 | 186.00 | " | 5.66 | 5.30 | 180.70 | " | 4.26 | 3.90 | 182.10 | 1.40 | 24°C |
| 6. | $W_6$ | Khera Buzurg | G.S.at Masjid | 7.15 | 1.30 | 0.28 | 181.00 | " | 4.75 | 4.47 | 176.53 | " | 3.45 | 3.17 | 177.83 | 1.30 | 24°C |
| 7. | $W_7$ | Narauli | KiranPal Singh | 7.02 | 1.23 | 0.30 | 180.00 | " | 4.60 | 4.30 | 175.70 | " | 3.25 | 2.95 | 177.05 | 1.35 | 24°C |
| 8. | $W_8$ | Safedpura | Jai Singh | 8.69 | 1.49 | 0.29 | 186.00 | " | 6.85 | 6.56 | 179.44 | " | 5.40 | 5.11 | 180.89 | 1.45 | 24°C |
| 9. | $W_9$ | Gwalra | Shri Ram | 8.40 | 0.85 | 0.65 | 184.00 | " | 7.37 | 6.72 | 177.28 | " | 5.88 | 5.23 | 178.77 | 1.49 | 26°C |
| 10. | $W_{10}$ | Bhawangarhi | Badri Prasad | 10.00 | 0.75 | 0.35 | 184.00 | " | 8.87 | 8.52 | 175.48 | " | 7.30 | 6.95 | 177.05 | 1.57 | 26°C |
| 11. | $W_{11}$ | Kalai | Ram Babu Singh | 7.60 | 0.72 | 0.65 | 185.00 | " | 6.50 | 5.85 | 179.15 | " | 4.58 | 3.93 | 181.07 | 1.92 | 25°C |
| 12. | $W_{12}$ | Mirpur | Ratan Lal | 6.40 | 0.95 | 0.40 | 181.00 | " | 5.60 | 5.20 | 175.80 | " | 4.22 | 3.82 | 177.18 | 1.38 | 25°C |

| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. | 17. | 18. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13. | $W_{13}$ | Bard Nadi | G.S. | 10.35 | 1.50 | 0.76 | 181.00 | 20.5.89 | 8.84 | 8.08 | 172.92 | 22.10.89 | 8.03 | 7.27 | 173.73 | 0.81 | 27°C |
| 14. | $W_{14}$ | Biswanpur | G.S. at Temple | 9.97 | 0.82 | 0.65 | 185.00 | " | 8.35 | 7.70 | 177.03 | " | 7.45 | 6.80 | 178.92 | 0.90 | 26°C |
| 15. | $W_{15}$ | Kothi Ka Nagla | Thakur Kundan Singh | 8.65 | 1.00 | 0.20 | 184.00 | " | 7.67 | 7.47 | 176.53 | " | 6.90 | 6.70 | 177.3 | 0.77 | 26°C |
| 16. | $W_{16}$ | Untgiri | G.S. | 8.10 | 2.00 | 1.20 | 184.00 | 21.5.89 | 6.35 | 5.15 | 178.85 | 23.10.89 | 5.24 | 4.04 | 179.96 | 1.11 | 26°C |
| 17. | $W_{17}$ | Rashupur | Ganga Ram | 9.65 | 1.15 | 0.80 | 186.00 | " | 7.87 | 7.07 | 178.93 | " | 7.00 | 6.20 | 179.80 | 0.87 | 26°C |
| 18. | $W_{18}$ | Chhirawali | G.S.At temple | 7.15 | 1.45 | 0.80 | 186.00 | " | 5.42 | 4.62 | 181.38 | " | 4.13 | 3.33 | 182.67 | 1.29 | 25°C |
| 19. | $W_{19}$ | Azamabad Machhua | Ran Singh | 6.75 | 1.10 | 0.35 | 185.00 | " | 5.45 | 5.10 | 179.90 | " | 4.28 | 3.93 | 181.07 | 1.17 | 25°C |
| 20. | $W_{20}$ | Sarmastpur | Raj Pal | 7.30 | 1.50 | 0.60 | 186.00 | " | 6.47 | 5.87 | 180.13 | " | 5.15 | 4.55 | 181.45 | 1.35 | 26°C |
| 21. | $W_{21}$ | Daudpur | Vijay Singh | 8.45 | 0.90 | 0.48 | 186.00 | " | 6.78 | 6.30 | 179.70 | " | 5.83 | 5.35 | 180.65 | 0.95 | 24°C |
| 22. | $W_{22}$ | Girdharpur | Daven Singh | 7.89 | 1.94 | 1.00 | 186.00 | " | 7.00 | 6.00 | 180.00 | " | 6.10 | 5.10 | 180.90 | 0.90 | 25°C |
| 23. | $W_{23}$ | Aurangabad | Sarban Singh | 7.40 | 0.90 | 0.50 | 187.00 | " | 5.85 | 5.35 | 181.65 | " | 4.35 | 3.85 | 183.15 | 1.50 | 26°C |
| 24. | $W_{24}$ | Shahpur | Lallu Chaudhry | 6.65 | 1.55 | 0.80 | 187.00 | " | 5.15 | 4.35 | 182.65 | " | 3.50 | 2.70 | 184.30 | 1.65 | 26°C |
| 25. | $W_{25}$ | Kondra | Bholamber | 5.50 | 1.65 | 0.70 | 184.00 | " | 4.60 | 3.90 | 180.10 | " | 3.80 | 3.10 | 180.90 | 0.80 | 26°C |
| 26. | $W_{26}$ | Darapur | Bevenai Ram | 5.92 | 1.30 | 0.42 | 184.00 | " | 4.95 | 4.53 | 179.47 | " | 4.30 | 3.88 | 180.12 | 0.65 | 26°C |
| 27. | $W_{27}$ | Ibrahimabad | Thain Singh | 5.90 | 0.90 | 0.70 | 184.00 | 22.5.89 | 4.60 | 3.90 | 180.10 | 24.10.89 | 3.88 | 3.18 | 180.85 | 0.72 | 26°C |
| 28. | $W_{28}$ | Gurshikran | BirPal | 7.20 | 1.55 | 0.80 | 183.00 | " | 6.50 | 5.70 | 177.30 | " | 5.60 | 4.80 | 178.20 | 0.90 | 26°C |
| 29. | $W_{29}$ | Barkatpur | NaruPal | 7.60 | 1.90 | 0.30 | 183.00 | " | 3.97 | 3.67 | 179.33 | " | 4.95 | 4.65 | 180.35 | 1.02 | 26°C |
| 30. | $W_{30}$ | Khan Alampur | KunwarPal | 5.50 | 0.75 | 0.10 | 182.00 | " | 4.80 | 4.70 | 179.30 | " | 3.32 | 3.22 | 178.78 | 1.48 | 27°C |

| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. | 17. | 18. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31. | $W_{31}$ | Mahmoodpur | Bissujit | 7.85 | 2.20 | 0.60 | 183.00 | 22.5.89 | 4.40 | 3.80 | 179.20 | 24.10.89 | 3.09 | 2.49 | 180.51 | 1.31 | 26°C |
| 32. | $W_{32}$ | Bhawan Khera | Biddya Devi | 7.00 | 0.85 | 0.50 | 183.00 | " | 5.58 | 5.08 | 177.92 | " | 3.66 | 3.16 | 179.84 | 1.92 | 26°C |
| 33. | $W_{33}$ | Bhojpur | Liladhar | 6.85 | 1.90 | 0.95 | 182.00 | " | 5.10 | 4.15 | 177.85 | " | 3.55 | 2.60 | 179.40 | 1.55 | 26°C |
| 34. | $W_{34}$ | Allahadadpur | Phool Singh | 7.20 | 0.75 | 0.80 | 183.00 | " | 5.95 | 5.15 | 177.85 | " | 4.70 | 3.90 | 179.10 | 1.25 | 25°C |
| 35. | $W_{35}$ | Shaika | Raj Pal Singh | 9.35 | 0.82 | 0.50 | 187.00 | " | 7.98 | 7.40 | 178.66 | " | 5.97 | 5.47 | 181.53 | 1.93 | 25°C |
| 36. | $W_{36}$ | Edalpur | Dasan Pal Singh | 6.20 | 1.65 | 0.00 | 185.00 | " | 5.00 | 5.00 | 178.00 | " | 3.14 | 3.14 | 181.86 | 1.86 | 26°C |
| 37. | $W_{37}$ | Khera Narayan Singh | Motilal | 6.62 | 0.78 | 0.80 | 183.00 | " | 5.85 | 5.05 | 177.95 | " | 4.59 | 3.79 | 179.21 | 1.26 | 25°C |
| 38. | $W_{38}$ | Balukhera | Ramji Lal gir | 6.20 | 0.88 | 0.25 | 183.00 | " | 5.90 | 5.65 | 177.35 | " | 4.40 | 4.15 | 178.85 | 1.50 | 24°C |
| 39. | $W_{39}$ | Rahana Singh pr | Mahabir | 7.60 | 0.95 | 0.80 | 183.00 | " | 4.87 | 4.07 | 178.93 | " | 3.70 | 2.90 | 180.10 | 1.17 | 24°C |
| 40. | $W_{40}$ | Jalupur Sehore | MunshiLal | 6.45 | 1.45 | 0.20 | 183.00 | " | 4.80 | 4.60 | 178.40 | " | 3.82 | 3.62 | 179.38 | 0.98 | 25°C |
| 41. | $W_{41}$ | Dumehra | Ram Lakhan | 6.40 | 2.20 | 0.38 | 183.00 | " | 4.88 | 4.50 | 178.50 | 25.10.89 | 3.88 | 3.50 | 179.50 | 1.00 | 26°C |
| 42. | $W_{42}$ | Jasratpur | Ghulab Singh | 6.70 | 1.35 | 0.30 | 184.00 | " | 5.05 | 4.75 | 179.25 | " | 4.02 | 3.72 | 180.28 | 1.03 | 26°C |
| 43. | $W_{43}$ | Panaithi | G.S. at Temple | 6.45 | 1.70 | 0.90 | 183.00 | " | 5.92 | 5.02 | 177.98 | " | 5.50 | 4.60 | 178.4 | 0.42 | 26°C |
| 44. | $W_{44}$ | Khangarhi | Shri Gopal | 6.80 | 1.05 | 0.75 | 182.00 | " | 5.90 | 5.15 | 176.85 | " | 5.80 | 5.05 | 176.95 | 0.10 | 25°C |
| 45. | $W_{45}$ | Ikri | Shamsher Ali | 6.66 | 1.70 | 0.60 | 184.00 | " | 5.60 | 5.00 | 179.00 | " | 5.42 | 4.82 | 179.18 | 0.18 | 26°C |
| 46. | $W_{46}$ | Pikhlauni | G.S. | 8.05 | 2.60 | 0.20 | 185.00 | " | 7.38 | 7.18 | 177.82 | " | 7.03 | 6.83 | 178.17 | 0.35 | 26°C |
| 47. | $W_{47}$ | Nijabatpura Borna | G.S. | 9.35 | 2.20 | 0.30 | 184.00 | " | 9.05 | 8.75 | 175.25 | " | 9.00 | 8.70 | 175.30 | 0.05 | 25°C |
| 48. | $W_{48}$ | Dhanipur | Rajendra Singh | 10.95 | 1.55 | 0.50 | 186.00 | " | 10.60 | 10.10 | 175.90 | " | 10.02 | 9.52 | 176.48 | 0.58 | 25°C |
| 49. | $W_{49}$ | Kamalpur | Kundan Singh | 12.43 | 1.30 | 0.00 | 183.00 | " | 11.02 | 11.02 | 171.98 | " | 10.63 | 10.63 | 172.37 | 0.39 | 26°C |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50. | $W_{50}$ | Hajipur Fateh Khan | Pitamber Singh | 14.90 | 1.80 | 0.25 | 184.50 | 23.5.89 | 13.50 | 13.25 | 171.25 | 25.10.89 | 13.29 | 13.04 | 171.46 | 0.21 | 25°C |
| 51. | $W_{51}$ | Gadrana | Harpat | 15.65 | 1.40 | 1.20 | 184.50 | " | 14.95 | 13.75 | 170.75 | " | 14.70 | 13.50 | 171.00 | 0.25 | 26°C |
| 52. | $W_{52}$ | Bhopatpur | Sonepal | 13.52 | 1.83 | 0.76 | 184.00 | " | 12.94 | 12.18 | 171.82 | " | 12.71 | 11.95 | 172.05 | 0.23 | 25°C |
| 53. | $W_{53}$ | Alipur | Harpal Singh | 14.30 | 1.20 | 0.60 | 182.00 | " | 13.86 | 13.26 | 168.74 | " | 13.67 | 13.07 | 168.93 | 0.19 | 27°C |
| 54. | $W_{54}$ | Mandrak (Rs.) | G.S. at R.S. | 18.10 | 2.50 | 0.70 | 182.70 | " | 15.90 | 15.20 | 167.50 | " | 15.75 | 15.05 | 167.65 | 0.15 | 27°C |
| 55. | $W_{55}$ | Shahbazpur | G.S. | 10.93 | 0.90 | 0.50 | 181.00 | " | 10.10 | 9.60 | 171.40 | " | 10.00 | 9.50 | 171.50 | 0.10 | 27°C |
| 56. | $W_{56}$ | Nagla Sirawali | Khiyali Ram | 12.72 | 2.60 | 0.60 | 181.00 | 24.5.89 | 11.10 | 10.50 | 170.50 | 26.10.89 | 10.90 | 10.30 | 170.70 | 0.20 | 25°C |
| 57. | $W_{57}$ | Dihauli | Yadu Ram Singh | 8.15 | 0.85 | 0.40 | 182.00 | " | 6.62 | 6.22 | 175.78 | " | 7.15 | 6.75 | 175.25 | 0.53 | 25°C |
| 58. | $W_{58}$ | Bham Kri Aibasi | G.S. at Temple | 8.50 | 1.30 | 0.80 | 183.00 | " | 6.55 | 5.75 | 177.25 | " | 6.60 | 5.80 | 177.20 | 0.05 | 25°C |
| 59. | $W_{59}$ | Gokalpur | G.S. | 7.90 | 1.00 | 0.60 | 183.00 | " | 6.90 | 6.30 | 176.70 | " | 6.62 | 6.02 | 176.98 | 0.28 | 25°C |
| 60. | $W_{60}$ | Saunauth Gokalpur | Radha Ballam Sharma | 9.70 | 2.30 | 0.80 | 183.00 | " | 8.25 | 7.45 | 175.55 | " | 7.78 | 6.98 | 176.02 | 0.47 | 27°C |
| 61. | $W_{61}$ | Bhartua | Rani Lakhmi Kumari | 10.40 | 1.65 | 0.40 | 182.00 | " | 9.50 | 9.10 | 172.90 | " | 9.03 | 8.63 | 173.37 | 0.47 | 27°C |
| 62. | $W_{62}$ | Gaznipur | Rishi Pal Singh | 10.00 | 1.35 | 0.10 | 182.00 | " | 9.70 | 9.60 | 172.40 | " | 9.25 | 9.15 | 172.85 | 0.45 | 27°C |
| 63. | $W_{63}$ | Adaun | Dhal Singh | 8.45 | 1.50 | 0.90 | 182.00 | " | 7.40 | 6.50 | 175.50 | " | 6.82 | 5.92 | 176.08 | 0.58 | 26°C |
| 64. | $W_{64}$ | Nagla Patel | Bir Pal Singh | 10.90 | 2.05 | 0.05 | 183.00 | " | 8.45 | 8.40 | 174.60 | " | 8.05 | 8.00 | 175.00 | 0.40 | 26°C |
| 65. | $W_{65}$ | Hardua | Shri Ganga Mandir | 6.05 | 1.35 | 0.85 | 186.00 | " | 4.60 | 3.75 | 182.25 | " | 3.92 | 3.07 | 182.93 | 0.68 | 26°C |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66. | $W_{66}$ | Dhasanna | Sunai Lal | 6.33 | 2.05 | 0.80 | 184.00 | 24.5.89 | 4.35 | 3.55 | 180.45 | 26.10.89 | 3.25 | 2.45 | 181.55 | 1.10 | 27°C |
| 67. | $W_{67}$ | Nagla Jadola | Asique Ali | 7.20 | 1.25 | 0.90 | 184.00 | " | 4.55 | 3.65 | 180.35 | 27.10.89 | 3.70 | 2.80 | 181.20 | 0.85 | 25°C |
| 68. | $W_{68}$ | Chengeri | Dhyan Pal | 7.47 | 1.20 | 0.90 | 183.00 | " | 5.35 | 4.45 | 178.55 | " | 3.65 | 2.75 | 180.25 | 1.75 | 26°C |
| 69. | $W_{69}$ | Midhula | Sone Pal | 5.90 | 1.25 | 1.00 | 184.00 | " | 4.40 | 3.40 | 180.60 | " | 2.83 | 1.83 | 182.17 | 1.57 | 26°C |
| 70. | $W_{70}$ | Nayabas | G.S. | 5.55 | 2.80 | 0.20 | 184.00 | " | 4.65 | 4.45 | 179.55 | " | 2.77 | 2.57 | 181.43 | 1.88 | 26°C |
| 71. | $W_{71}$ | Bhatula | Bal Singh | 5.55 | 1.50 | 0.40 | 184.00 | 25.5.89 | 4.45 | 4.05 | 179.95 | " | 2.07 | 1.67 | 182.33 | 2.38 | 26°C |
| 72. | $W_{72}$ | Nagla Bhagu | Mohan Lal | 5.40 | 2.20 | 0.70 | 182.00 | " | 3.90 | 3.20 | 178.80 | " | 2.10 | 1.40 | 180.60 | 1.80 | 26°C |
| 73. | $W_{73}$ | Daulatpur | Panna Lal | 6.25 | 1.15 | 0.40 | 184.00 | " | 4.75 | 4.35 | 179.65 | " | 2.53 | 2.13 | 181.87 | 2.22 | 27°C |
| 74. | $W_{74}$ | Shekhupur | Diwan Singh | 6.30 | 1.25 | 0.35 | 183.00 | " | 5.28 | 4.93 | 178.07 | " | 3.39 | 3.04 | 179.96 | 1.89 | 27°C |
| 75. | $W_{75}$ | Khitkari | Babu Singh | 6.70 | 1.35 | 0.45 | 183.00 | " | 5.90 | 4.45 | 178.55 | " | 3.52 | 3.07 | 179.93 | 2.38 | 27°C |
| 76. | $W_{76}$ | Nagla Bak Sullah Khan | G.S. at Dharmsala | 6.40 | 1.35 | 0.40 | 184.00 | " | 5.85 | 5.45 | 178.55 | " | 4.80 | 4.40 | 179.60 | 1.05 | 27°C |
| 77. | $W_{77}$ | Dindayalpur | Rajkumar Singh | 6.06 | 0.90 | 0.80 | 184.00 | 26.5.89 | 5.18 | 4.38 | 179.62 | 28.10.89 | 3.66 | 2.86 | 181.14 | 1.52 | 26°C |
| 78. | $W_{78}$ | Bundasi | Ram Singh | 7.05 | 1.20 | 0.40 | 185.00 | " | 4.74 | 4.34 | 180.66 | " | 3.24 | 2.84 | 182.16 | 1.50 | 26°C |
| 79. | $W_{79}$ | Nagla Dhram Singh | Ramu Singh | 9.90 | 1.95 | 0.52 | 185.00 | " | 8.14 | 7.62 | 177.38 | " | 7.28 | 6.76 | 178.24 | 0.86 | 26°C |
| 80. | $W_{80}$ | Bahrampur | G.S. | 7.90 | 0.96 | 1.00 | 185.00 | " | 6.50 | 5.50 | 179.50 | " | 5.59 | 4.59 | 180.41 | 0.91 | 26°C |
| 81. | $W_{81}$ | Tajpur | Mahmood | 6.98 | 0.65 | 1.02 | 185.00 | " | 6.61 | 5.59 | 179.41 | " | 5.59 | 4.57 | 180.43 | 1.02 | 25°C |
| 82. | $W_{82}$ | Aminabad | G.S. | 6.02 | 1.02 | 0.95 | 184.00 | " | 5.64 | 4.69 | 179.31 | " | 4.13 | 3.18 | 180.82 | 1.51 | 26°C |
| 83. | $W_{83}$ | Jalali | G.S. | 6.07 | 2.20 | 0.45 | 184.00 | " | 5.06 | 4.61 | 179.39 | " | 3.27 | 2.82 | 181.18 | 1.79 | 24°C |
| 84. | $W_{84}$ | Nagla Khumi | Ram Prasad | 5.90 | 0.80 | 0.71 | 184.00 | " | 5.41 | 4.70 | 179.30 | " | 3.98 | 3.27 | 180.73 | 1.43 | 24°C |
| 85. | $W_{85}$ | Nagla Mehdi Ali | G.S. | 5.80 | 1.15 | 0.69 | 183.00 | " | 5.12 | 4.43 | 178.57 | " | 3.88 | 3.19 | 179.81 | 1.24 | 24°C |
| 86. | $W_{86}$ | Ukauli | Gokul Pal | 6.10 | 0.94 | 0.90 | 183.00 | " | 5.39 | 4.49 | 178.51 | " | 3.50 | 2.60 | 180.40 | 1.89 | 25°C |

APPENDIX - 3 (A)

RESULT OF PARTIAL CHEMICAL ANALYSIS OF WATER SAMPLES COLLECTED FROM OBSERVATION WELL NET WORK STATIONS OF DHANIPUR BLOCK OF KOIL TEHSIL, DISTRICT - ALIGARH (U.P.) IN MAY 1989

(RESULT IN PPm)

| S.No. | Sample No. | Location | Temp. | PH | E.C. (microm-hos/cm at 25°C) | $CO_3^{--}$ | $HCO_3^-$ | $Cl^-$ | $SO_4$ | $Na^+$ | $K^+$ | $Ca^{++}$ | $Mg^+$ | T.H. | T.D.S. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1. | $S_1$ | Morthal | 25°C | 6.93 | 778 | 60 | 549 | 92 | 139 | 44 | 184 | 37 | 32 | 202 | 498 |
| 2. | $S_2$ | Ukhlana | 24°C | 7.95 | 2460 | 270 | 714 | 526 | 417 | 298 | 491 | 10 | 44 | 460 | 1574 |
| 3. | $S_3$ | Bara Nadi | 27°C | 7.53 | 721 | 60 | 519 | 71 | 367 | 107 | 15 | 70 | 64 | 212 | 462 |
| 4. | $S_4$ | Girdharpur | 25°C | 8.05 | 774 | 72 | 641 | 96 | 319 | 80 | 20 | 56 | 37 | 308 | 496 |
| 5. | $S_5$ | Nagla Sirawali | 25°C | 7.83 | 851 | 60 | 805 | 131 | 200 | 189 | 15 | 67 | 20 | 366 | 545 |
| 6. | $S_6$ | Adun | 26°C | 7.70 | 1296 | 60 | 567 | 170 | 337 | 131 | 220 | 51 | 38 | 296 | 880 |
| 7. | $S_7$ | Alipur | 27°C | 7.86 | 1752 | 72 | 1141 | 383 | 52 | 243 | 21 | 17 | 37 | 220 | 1122 |
| 8. | $S_8$ | Dhanipur | 25°C | 7.96 | 697 | 30 | 640 | 167 | 179 | 116 | 13 | 40 | 31 | 190 | 446 |
| 9. | $S_9$ | Julupur Sihore | 25°C | 7.88 | 584 | 54 | 500 | 121 | 244 | 62 | 63 | 19 | 25 | 160 | 374 |
| 10. | $S_{10}$ | Rohana Singhpur | 24°C | 7.75 | 2290 | 42 | 1202 | 469 | 355 | 220 | 332 | 33 | 49 | 268 | 1466 |
| 11. | $S_{11}$ | Balu Khera | 24°C | 7.82 | 1553 | 12 | 1013 | 291 | 69 | 253 | 145 | 43 | 48 | 260 | 994 |
| 12. | $S_{12}$ | Kothi Ka Nagla | 26°C | 7.79 | 783 | 30 | 909 | 107 | 305 | 192 | 23 | 21 | 16 | 118 | 502 |
| 13. | $S_{13}$ | Mahmoodpur | 26°C | 7.78 | 601 | 18 | 494 | 149 | 170 | 97 | 10 | 37 | 29 | 252 | 385 |
| 14. | $S_{14}$ | Bhawangarhi | 26°C | 7.96 | 677 | 54 | 537 | 114 | 130 | 143 | 13 | 21 | 29 | 144 | 434 |
| 15. | $S_{15}$ | Khangarhi | 25°C | 7.64 | 1334 | 72 | 818 | 238 | 403 | 240 | 11 | 13 | 50 | 152 | 854 |
| 16. | $S_{16}$ | Pikhlauni | 26°C | 7.84 | 1098 | 120 | 458 | 231 | 225 | 210 | 71 | 24 | 33 | 200 | 703 |
| 17. | $S_{17}$ | Shahpur | 26°C | 7.48 | 325 | 24 | 324 | 132 | 178 | 133 | 17 | 47 | 18 | 188 | 208 |
| 18. | $S_{18}$ | Shamastpur | 26°C | 7.74 | 870 | 30 | 445 | 178 | 140 | 15 | 38 | 26 | 32 | 222 | 557 |
| 19. | $S_{19}$ | Dhasanna | 27°C | 7.70 | 903 | 36 | 684 | 195 | 202 | 144 | 60 | 62 | 32 | 312 | 578 |
| 20. | $S_{20}$ | Gaznipur | 27°C | 8.03 | 1566 | 60 | 854 | 327 | 409 | 206 | 16 | 27 | 40 | 302 | 1003 |
| 21. | $S_{21}$ | Changeri | 26°C | 7.78 | 522 | 60 | 409 | 131 | 67 | 57 | 10 | 49 | 24 | 200 | 334 |

Contd........P.2.

- 2 -

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22. | $S_{22}$ | Bhartua | 27°C | 7.86 | 603 | 30 | 683 | 103 | 44 | 86 | 12 | 32 | 43 | 266 | 386 |
| 23. | $S_{23}$ | Rashupur | 26°C | 7.80 | 440 | 6 | 470 | 57 | 124 | 22 | 9 | 28 | 33 | 210 | 282 |
| 24. | $S_{24}$ | Edalpur | 26°C | 7.75 | 482 | 6 | 494 | 82 | 387 | 54 | 12 | 57 | 20 | 168 | 309 |
| 25. | $S_{25}$ | Nayabas | 26°C | 8.08 | 564 | 36 | 531 | 89 | 227 | 67 | 3 | 24 | 33 | 192 | 361 |
| 26. | $S_{26}$ | Bhudansi | 26°C | 7.88 | 324 | 6 | 299 | 89 | 148 | 10 | 24 | 38 | 21 | 160 | 208 |
| 27. | $S_{27}$ | Iasratpur | 26°C | 7.88 | 368 | 36 | 391 | 78 | 89 | 25 | 10 | 34 | 27 | 208 | 236 |
| 28. | $S_{28}$ | Kondra | 26°C | 7.70 | 800 | 18 | 751 | 160 | 318 | 107 | 27 | 79 | 23 | 316 | 512 |
| 29. | $S_{29}$ | Khan Alampur | 27°C | 7.88 | 662 | 24 | 683 | 110 | 199 | 134 | 11 | 21 | 31 | 174 | 424 |

## APPENDIX - 3 (B)

**CHEMICAL ANALYSIS DATA OF WATER SAMPLES COLLECTED FROM OBSERVATION WELL NET WORK STATIONS OF DHANIPUR BLOCK OF KOIL TEHSIL, DISTRICT-ALIGARH (U.P.)**

(RESULT IN epm)

| Sl. No. | Sample | Location | Temp. | PH | E.C. micromhos/cm at 25°C | Na | K | Ca | Mg | S.A.R. | % $Na^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1. | $S_1$ | Morthal | 25°C | 6.93 | 778 | 1.91 | 4.71 | 1.85 | 2.63 | 1.28 | 59.64 |
| 2. | $S_2$ | Ukhlana | 24°C | 7.95 | 2460 | 12.96 | 12.56 | 0.50 | 3.62 | 9.03 | 66.10 |
| 3. | $S_3$ | Bara Nadi | 27°C | 7.53 | 721 | 4.65 | 0.38 | 3.49 | 5.26 | 2.22 | 36.50 |
| 4. | $S_4$ | Girdharpur | 25°C | 8.05 | 774 | 3.48 | 0.51 | 2.79 | 3.04 | 2.04 | 40.63 |
| 5. | $S_5$ | Nagla Sirawali | 25°C | 7.83 | 851 | 8.22 | 0.38 | 3.34 | 1.64 | 5.21 | 63.32 |
| 6. | $S_6$ | Adun | 26°C | 7.70 | 1296 | 5.70 | 5.63 | 2.54 | 3.12 | 3.39 | 66.69 |
| 7. | $S_7$ | Alipur | 27°C | 7.86 | 1752 | 10.57 | 0.54 | 0.85 | 3.04 | 7.58 | 74.07 |
| 8. | $S_8$ | Dhanipur | 25°C | 7.96 | 697 | 5.04 | 0.33 | 2 | 2.55 | 3.34 | 54.13 |
| 9. | $S_9$ | Julupur Sihore | 25°C | 7.88 | 584 | 2.70 | 1.61 | 0.95 | 2.06 | 2.20 | 58.88 |
| 10. | $S_{10}$ | Rohana Singhpur | 24°C | 7.75 | 2290 | 9.57 | 8.49 | 1.65 | 4.03 | 5.68 | 76.07 |
| 11. | $S_{11}$ | Balukhera | 24°C | 7.82 | 1553 | 11 | 3.71 | 2.15 | 3.95 | 6.30 | 70.69 |
| 12. | $S_{12}$ | Kothika Nagla | 26°C | 7.79 | 783 | 8.35 | 0.59 | 1.05 | 1.32 | 7.67 | 79.05 |
| 13. | $S_{13}$ | Mahmoodpur | 26°C | 7.78 | 601 | 4.22 | 0.26 | 1.85 | 2.38 | 2.90 | 51.44 |
| 14. | $S_{14}$ | Bhawangarhi | 26°C | 7.90 | 677 | 6.22 | 0.33 | 1.05 | 2.38 | 4.75 | 65.63 |
| 15. | $S_{15}$ | Khangarhi | 25°C | 7.64 | 1334 | 10.43 | 0.28 | 0.65 | 4.11 | 6.76 | 69.23 |
| 16. | $S_{16}$ | Pikhlauni | 26°C | 7.84 | 1098 | 9.13 | 1.82 | 1.20 | 2.71 | 6.53 | 73.69 |
| 17. | $S_{17}$ | Shahpur | 26°C | 7.48 | 325 | 5.78 | 0.43 | 2.35 | 1.48 | 4.18 | 61.85 |
| 18. | $S_{18}$ | Shamastpur | 26°C | 7.74 | 870 | 0.65 | 0.97 | 1.30 | 2.63 | 0.46 | 29.19 |
| 19. | $S_{19}$ | Dhasanna | 27°C | 7.70 | 903 | 6.26 | 1.53 | 3.09 | 2.63 | 3.70 | 57.66 |
| 20. | $S_{20}$ | Gaznipur | 27°C | 8.03 | 1566 | 8.96 | 0.41 | 1.35 | 3.29 | 5.88 | 66.88 |
| 21. | $S_{21}$ | Changeri | 26°C | 7.78 | 522 | 2.48 | 0.26 | 2.45 | 1.97 | 1.67 | 38.27 |
| 22. | $S_{22}$ | Bhartua | 27°C | 7.86 | 603 | 3.74 | 0.31 | 1.60 | 3.54 | 2.33 | 44.07 |
| 23. | $S_{23}$ | Rashupur | 26°C | 7.80 | 440 | 0.96 | 0.23 | 1.40 | 2.71 | 0.67 | 22.45 |
| 24. | $S_{24}$ | Edalpur | 26°C | 7.75 | 482 | 2.35 | 0.31 | 2.84 | 1.64 | 1.57 | 37.25 |
| 25. | $S_{25}$ | Nayabas | 26°C | 8.08 | 564 | 2.91 | 0.08 | 1.20 | 2.71 | 2.08 | 43.33 |
| 26. | $S_{26}$ | Bhudansi | 26°C | 7.88 | 324 | 0.43 | 0.61 | 1.90 | 1.73 | 0.32 | 22.27 |
| 27. | $S_{27}$ | Jasratpur | 26°C | 7.88 | 369 | 1.09 | 0.26 | 1.70 | 2.22 | 0.78 | 25.62 |
| 28. | $S_{28}$ | Kondra | 26°C | 7.70 | 800 | 4.66 | 0.69 | 3.94 | 1.89 | 2.73 | 47.85 |
| 29. | $S_{29}$ | Khan Alampur | 27°C | 7.88 | 662 | 5.83 | 0.28 | 1.05 | 2.55 | 4.35 | 62.92 |

APPENDIX - 4

**TRACE ELEMENTS DATA** (BY ATOMIC ABSORPTION SPECTROPHOTOMETRE) OF COLLECTED WATER SAMPLES FROM DUG WELLS IN DHANIPUR BLOCK OF KOIL TEHSIL, DISTRICT - ALIGARH (U.P.) IN MAY 1989

| S.No. | Sample | Location | Fe | Mn | Zn | Cu | Ni | Co | Pb | Cd | Cr | Li | Rb | Ba | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | $S_1$ | Rashupur | 0.095 | 0.162 | 0.148 | 0.057 | 0.030 | 0.061 | Nil | 0.035 | 0.061 | 0.042 | 0.215 | 0.047 | 0.126 |
| 2. | $S_2$ | Nagla Sirawali | 0.438 | 0.066 | 0.165 | 0.029 | 0.023 | 0.073 | Nil | 0.045 | 0.067 | 0.052 | 0.170 | 0.065 | 0.112 |
| 3. | $S_3$ | Bhudansi | 0.202 | 0.309 | 0.079 | 0.049 | 0.035 | 0.078 | Nil | 0.033 | 0.037 | 0.032 | 0.140 | 0.106 | 0.092 |
| 4. | $S_4$ | Adun | 0.138 | 0.192 | 0.195 | 0.040 | 0.017 | 0.088 | 0.013 | 0.050 | 0.079 | 0.065 | 0.221 | 0.036 | 0.721 |
| 5. | $S_5$ | Rohana Singhpur | 0.136 | 0.11 | 0.235 | 0.074 | 0.037 | 0.086 | 0.065 | 0.070 | 0.073 | 0.123 | 0.270 | 0.030 | 0.817 |
| 6. | $S_6$ | Khan Alampur | 0.377 | 0.094 | 0.162 | 0.054 | 0.026 | 0.073 | 0.075 | 0.052 | 0.067 | 0.160 | 0.193 | 0.028 | 0.089 |
| 7. | $S_7$ | Edalpur | 0.175 | 0.071 | 0.067 | 0.016 | 0.024 | 0.061 | 0.087 | 0.039 | 0.037 | 0.055 | 0.215 | 0.025 | 0.881 |
| 8. | $S_8$ | Kondra | 0.129 | 0.122 | 0.158 | 0.024 | 0.033 | 0.073 | Nil | 0.043 | 0.039 | 0.075 | 0.127 | 0.043 | 0.149 |

## APPENDIX - 5

LITHOLOGICAL LOGS OF BOREHOLES DRILLED BY STATE TUBEWELL DEPARTMENT - DHANIPUR BLOCK, DISTRICT ALIGARH

I. TUBEWELL No. - 143

LOCATION - Isanpur

Drilling started on - 31-12-80

Drilling completed on 8-01-81

| Lithology | Depth range in metre b.g.l. | Thickness in metre |
|---|---|---|
| Surface clay | 0.00-6.10 | 6.10 |
| Sandy clay & Kankar | 6.10-18.30 | 12.20 |
| Sandy clay | 18.30-24.40 | 6.10 |
| Fine to medium sand | 24.40-91.56 | 67.16 |
| Clay | 91.56-95.55 | 3.99 |

2. TUBEWELL No. - 124

Location - Shabazpur

Drilling started on 1-12-79

Drilling completed on 20-12-79

| Lithology | Depth range in metre b.g.l. | Thickness in metre |
|---|---|---|
| Surface clay | 0.00-6.10 | 6.10 |
| Very fine sand | 6.10-12.20 | 6.10 |
| Fine sand | 12.20-30.50 | 18.30 |
| Fine to medium sand | 30.50-36.60 | 6.10 |
| Clay Kankar | 36.60-42.70 | 6.10 |
| Fine sand | 42.70-48.80 | 6.10 |
| Fine to medium sand | 48.80-67.10 | 18.30 |
| Yellow fine to medium sand | 67.10-79.50 | 12.20 |
| Fine to medium sand | 79.30-91.50 | 12.20 |
| Hard clay | 91.50-103.00 | 11.50 |
| Fine sand & Stone | 103.00-136.00 | 33.00 |
| Clay (caving) | 136.00-154.00 | 18.00 |

3. TUBEWELL No. 163

LOCATION - Khan garhi

Drilling started on - 11.2.82

Drilling completed on - 16.2.82

| Lithology | Depth range in metre b.g.l. | Thickness in metre |
|---|---|---|
| Surface clay | 0.00 - 2.44 | 2.44 |
| Hard clay | 2.44 - 6.10 | 3.66 |
| Very fine sand | 6.10 - 9.15 | 3.05 |
| Fine sand | 9.15 - 12.20 | 3.05 |
| Medium sand | 12.20 - 21.35 | 9.15 |
| Hard clay | 21.35 - 24.40 | 3.05 |
| Very fine sand | 24.40 - 27.45 | 3.05 |
| Medium sand | 27.45 - 36.60 | 9.15 |
| Yellow fine sand | 36.60 - 39.65 | 3.05 |
| Medium sand with sand stone | 39.65 - 51.85 | 12.20 |
| Hard clay | 51.85 - 67.10 | 15.25 |
| Hard clay with hard stone | 67.10 - 70.15 | 3.05 |
| Yellow fine sand | 70.15 - 76.25 | 6.10 |
| Hard clay | 76.25 - 103.69 | 27.44 |
| Very fine sand | 103.69 - 106.74 | 3.05 |
| Hard clay | 106.74 - 109.79 | 3.05 |
| Fine sand & stone | 109.79 - 148.00 | 38.21 |
| Hard clay & hard stone | 148.00 - 160.01 | 11.99 |

4. TUBEWELL No. 162
Location - Darapur
Drilling started on 18.9.81
Drilling completed on 26.9.81

| Lithology | Depth range in metre b.g.l. | Thickness in metre |
|---|---|---|
| Surface clay | 0.00 - 4.57 | 4.57 |
| Sandy clay | 4.57 - 7.62 | 3.05 |
| Fine to medium sand | 7.62 - 16.77 | 9.15 |
| Clay & Kankar | 16.67 - 22.87 | 6.10 |
| Fine to medium sand | 22.87 - 30.49 | 7.62 |
| Hard clay & Kankar | 30.49 - 37.20 | 6.71 |
| Fine to medium sand | 37.20 - 41.16 | 3.96 |
| Medium sand and sand stone | 41.16 - 48.78 | 7.62 |
| Hard clay & Kankar | 48.78 - 82-32 | 33.54 |
| Fine to medium sand & Kankar | 82.32 - 91-47 | 9.15 |
| Hard clay & Kankar | 91.47 - 96.04 | 4.57 |
| Hard clay | 96.04 - 99.09 | 3.05 |
| Hard stone | 99.09 - 103.66 | 4.57 |
| Sandy Clay | 103.66 - 105.18 | 1.52 |
| Clay, Kankar & hard stone | 105.18 - 108.23 | 3.05 |
| Fine sand & sand stone | 108.23 - 111.28 | 3.05 |
| Clay & Kankar | 111.28 - 120.43 | 9.15 |
| Very fine sand | 120.43 - 160.06 | 39.63 |
| Clay, Kankar, Laha & Stone | 160.06 - 243.90 | 83.84 |

5. TUBEWELL No. 84

Location - Bhartua

Drilling started on 8.6.65

Drilling completed on 9.6.65

| Lithology | Depth range in metre b.g.l. | | | Thickness in metre |
|---|---|---|---|---|
| Surface clay | 0.00 | - | 3.05 | 3.05 |
| Lehal Kankar | 3.05 | - | 6.10 | 3.05 |
| Clay Kankar | 6.10 | - | 13.72 | 7.62 |
| Sand fine | 13.72 | - | 16.77 | 3.05 |
| Fine to medium sand | 16.77 | - | 21.34 | 4.57 |
| Clay Kankar | 21.34 | - | 25.91 | 5.57 |
| Fine to medium sand | 25.91 | - | 31.09 | 5.18 |
| Lehal | 31.09 | - | 34.14 | 3.05 |
| Lehal & Kankar | 34.14 | - | 37.80 | 3.66 |
| Kankar & Stone | 37.80 | - | 40.85 | 3.05 |
| Hard Clay & Kankar | 40.85 | - | 43.90 | 3.05 |
| Hard Clay & Kankar sticky | 43.90 | - | 46.95 | 3.05 |
| Fine to medium sand stone | 46.95 | - | 56.10 | 9.15 |
| Medium sand | 56.10 | - | 58.23 | 2.13 |
| Loose caving clay | 58.23 | - | 64.102 | 5.79 |
| Fine sand | 64.02 | - | 92.00 | 27.98 |
| Hard clay | 92.00 | - | 108.05 | 16.05 |
| Very fine sand & Kankar | 108.05 | - | 146.00 | 37.95 |
| Clay | 146.00 | - | 160.00 | 14.00 |

6. **TUBWELL** No. 172

Location - Pikhlauni

Drilling started on 14.8.85

Drilling completed on 7.9.85

| Lithology | Depth range in metre b.g.l. | | | Thickness in metre |
|---|---|---|---|---|
| Surface clay with Kankar | 00.00 | - | 5.18 | 5.18 |
| Clay & Kankar | 5.18 | - | 7.62 | 2.44 |
| Fine sand, sand stone & Kankar | 7.62 | - | 10.67 | 3.05 |
| Fine sand | 10.67 | - | 16.77 | 6.10 |
| Clay & Kankar | 16.77 | - | 19.82 | 3.05 |
| Fine sand & Stone clay | 19.82 | - | 22.87 | 3.05 |
| Yellow fine sand | 22.87 | - | 25.92 | 3.05 |
| Fine sand | 25.92 | - | 28.97 | 3.05 |
| Clay | 28.97 | - | 33.54 | 4.57 |
| Fine sand & Sand stone | 34.54 | - | 38.11 | 4.57 |
| Fine to medium sand & sand stone | 38.11 | - | 49.70 | 11.59 |
| Clay & Kankar | 49.70 | - | 62.50 | 12.80 |
| Clay & Kankar (Caving) | 62.50 | - | 109.76 | 47.26 |
| Fine sand & Stone | 109.76 | - | 113.11 | 3.35 |
| Loose Clay | 113.11 | - | 138.72 | 25.61 |
| Clay & hard stone | 138.72 | - | 144.82 | 6.10 |
| Clay (caving) | 144.82 | - | 153.97 | 9.15 |
| Sandy clay | 153.97 | - | 160.07 | 6.10 |
| Clay | 160.07 | - | 166.17 | 6.10 |
| Very hard stone | 166.17 | | 166.47 | 0.30 |

7. TUBEWELL - 107

Location - Khan Alampur

Drilling started on 8.4.71

Drilling completed on 12.4.71

| Lithology | Depth range in metre b.g.l. | | | Thickness in metre |
|---|---|---|---|---|
| Surface clay | 0.00 | - | 3.05 | 3.05 |
| Clay & Kankar | 3.05 | - | 9.15 | 6.10 |
| Very fine sand | 9.15 | - | 12.20 | 3.05 |
| Fine sand | 12.20 | - | 15.25 | 3.05 |
| Good fine sand | 15.25 | - | 19.82 | 4.57 |
| Clay & Kankar | 19.82 | - | 24.39 | 4.57 |
| Fine sand | 24.39 | - | 36.59 | 12.20 |
| Fine to medium sand | 36.59 | - | 39.64 | 3.05 |
| Fine to medium sand stone | 39.64 | - | 42.69 | 3.05 |
| Good fine sand | 42.69 | - | 48.79 | 6.10 |
| Medium sand & Bajry | 48.79 | - | 51.84 | 3.05 |
| Clay & Kankar | 51.84 | - | 57.94 | 6.10 |
| Caving clay & Kankar | 57.94 | - | 60.99 | 3.05 |
| Hard clay & Kankar | 60.99 | - | 73.19 | 12.20 |
| Clay & hard stone | 73.19 | - | 102.00 | 28.81 |
| Fine sand & sand stone | 102.00 | - | 138.00 | 36.00 |

8. TUBEWELL - 111

Location - Kamalpur

Drilling started on 17.1.77

Drilling completed on 20.1.77

| Lithology | Depth range in metre b.g.l. | | | Thickness in metre |
|---|---|---|---|---|
| Surface clay | 0.00 | - | 6.10 | 6.10 |
| Clay | 6.10 | - | 9.15 | 3.05 |
| Sand clay | 9.15 | - | 12.20 | 3.05 |
| Fine sand | 12.20 | - | 24.40 | 12.20 |
| Medium sand | 24.40 | - | 38.80 | 14.40 |
| Clay | 38.80 | - | 42.90 | 4.10 |
| Fine sand with sand stone | 42.90 | - | 48.80 | 5.90 |
| Medium sand with stone | 48.80 | - | 68.10 | 19.30 |
| Clay & Kankar | 68.10 | - | 79.90 | 11.80 |
| Yellow fine sand | 79.90 | - | 82.35 | 2.45 |
| Fine sand | 82.35 | - | 85.00 | 2.65 |
| Fine to medium sand | 85.00 | - | 95.00 | 10.00 |
| Clay | 95.00 | - | 106.75 | 11.75 |
| Fine sand & stone | 106.75 | - | 130.80 | 24.05 |
| Yellow fine sand | 130.80 | - | 152.00 | 21.20 |